NUCLEONIX

CATALOG ON
HEALTH PHYSICS INSTRUMENTATION
FOR

- **RADIOTHERAPY**
- **NUCLEAR MEDICINE**
- **DIAGNOSTIC RADIOLOGY**
- **MEDICAL PHYSICS**
- **MEDICAL CYCLOTRON FACILITIES**

Excellence in Nuclear Instrumentation

- Hand-Held Portable Radiation Survey Meters
- Beta-Gamma Radiation Survey Meters
- Digital Contamination Monitors
- Very Low Level Survey Meters
- Digital Pocket Dosimeters
- Area Gamma Monitors
- Networking Software (Gamma Link)
- Gamma Ray Spectrometer, with well type scintillation detector, with 8K MCA system
- Beta Gamma Hand, Foot and Clothing Monitors
- TLD Research Reader (for Medical dosimetry) / TLD Badge Reader (for Personnel Monitoring)

NUCLEONIX SYSTEMS PVT. LTD.
Plot No.162 A & B, Phase-II, IDA, Cherlapally, Hyderabad-500051 INDIA.
Ph :+91-40-27263701, 32918055, 32914548 Fax : 040-27262146
E-mail : info@nucleonix.com website : www.nucleonix.com

INTRODUCTION

Nucleonix Systems (P) Ltd. founded in the year 1990 carries rich product design and manufacturing experience in the field of Nuclear & Radiation Monitoring Instrumentation. The company is primarily established to meet the partial requirements of the above said instrumentation in Nuclear Research Centres, Atomic Power Stations, Radiotherapy Departments, Nuclear medicine centres, Cyclotron PET-CT centres and other Radiological Installations, apart from meeting the requirements for university education, Industry, Defense & Homeland Security.

Since Nucleonix Systems has wide range of products an attempt has been made to bring out an exclusive catalog on **Health Physics Instrumentation** for applications in **Medical Physics, Radiotherapy, Nuclear Medicine & Cyclotron PET-CT centres**.

With a strong base in the manufacturing of Nuclear Counting Systems & Modular Instrumentation for various applications, Nucleonix Systems ventured into manufacturing of Portable Radiation Monitors with technology transfer agreement from Bhabha Atomic Research Centre in April 1990 Mumbai a premier Research Institute in Nuclear Sciences. Based on the above technology in the year 1990 itself a few types of **Hand held portable radiation survey meters** & a **digital contamination monitor** were introduced. Over the years these designs were totally modified.

Further in the year 1992 Nucleonix Systems developed **Area Gamma Monitor** in the range (0-100mR/hr) useful for cancer hospitals for installations near Teletherapy, Brachytherapy, & other machines (medical systems). These are installed to monitor **gamma dose rate**s continuously & produce alarms when dose rates exceed preset alarm levels, during the course of use of these therapy machines by medical physicists & oncologists.

Year 1993 was another milestone. A first **PC based Thermoluminescence Dosimeter Reader** was developed and introduced to acquire and analyse digitized TL glow curve. This system was initially offered with DOS based software. A more compact system with WINDOWS based software with special application module for medical dosimetry was made available in 1996. This system finds applications in Low Level Radiation Measurements. TL Phosphor development and characterization etc., apart from the its applications in **medical dosimetry**.

Two more portable monitors namely **Environmental Radiation Dosimeter** and **Micro-R-Survey Meter** were introduced in the year 1994 for Low Level Radiation Measurements.

However during years (2005-2007) designs of most of these portable radiation monitors which include survey meters for gamma & beta-gamma measurement, digital contamination monitors, Micro-R-Survey Meter, were improved & standardized to have uniform design features. Monitors were provided with measuring units, both in **'R'** & **Sv',** apart from **CPS** & **CPM** modes wherever required. Additional storage facility with data down loading facility into PC was also added.

In the year 2008 another important development was achieved i.e., First Indian developed **Custom LCD analog scale version portable radiation survey meter** was launched and various models of portable meters based around this technology, were introduced.

Area gamma monitor was upgraded in design for cancer hospital users with optimal features to slightly bring down the cost. Two models one with **built-in detector** & the other with **external detector probe** with user choice of cable length between measuring unit & detector probe are made available. These are popular with most of the Radiotherapy departments in various cancer hospitals & also with medical systems companies in India.

Year 2008/2009 lead to another important development in the area of pocket dosimeters. Si-diode detector based two types of pocket dosimeters were launched, namely **'Pen type pocket dosimeter'** to compute & display both dose & dose rate & the other model is waist belt worn type **alarm dosimeter** with **docking station**. A '**personnel dose records data management software'** also has been developed. This will be a good package for institutions who would like to maintain dose records data of personnel in a Radiotherapy department/Nuclear medicine centre or a cyclotron PET-CT centre.

In the year 2011 - 2012, compact single board version Portable meters in Plastic Enclosure, were developed & introduced. In the year 2012, we have signed a Technology transfer agreement with BARC who have transferred technology in respect of kVp meter & Exposure Timer a quality assurance meter to measure kVp & Exposure Time in diagnostic X-ray machines.

Nucleonix Systems is committed to develop, Manufacture and supply state-of-art products to meet the requirements in Radiotherapy Departments, Nuclear medicine centres, cyclotron PET-CT centres and other Radiological installations. Nucleonix Systems is a support oriented company dedicated for the above cause.

J. Narender Reddy
Managing Director

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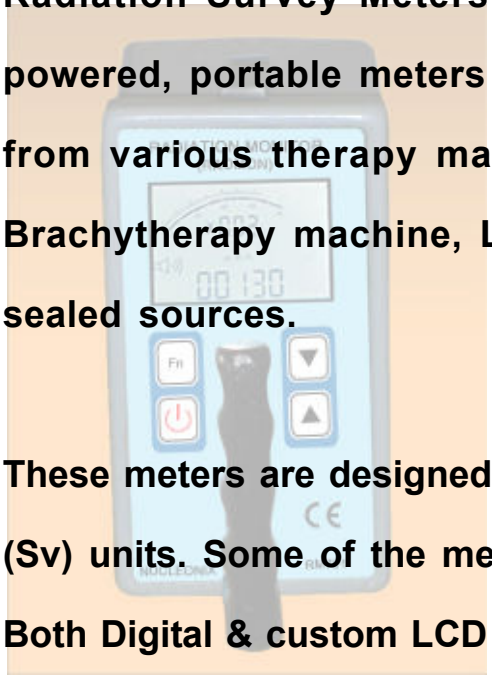
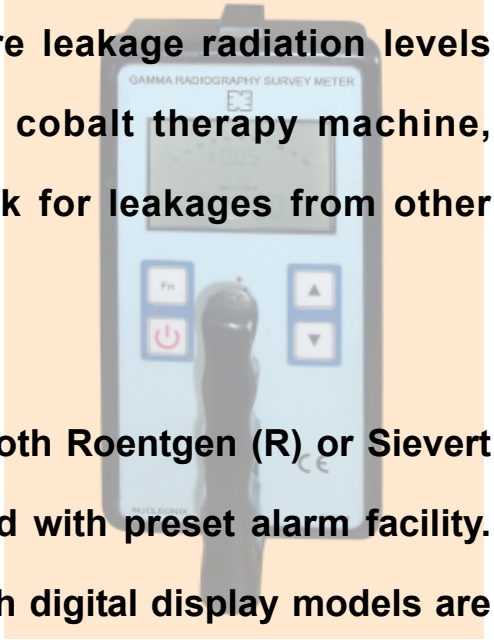
RADIATION SURVEY METERS

Radiation Survey Meters are general class of hand held, battery powered, portable meters used to measure leakage radiation levels from various therapy machines such as cobalt therapy machine, Brachytherapy machine, Linac or to check for leakages from other sealed sources.





These meters are designed to show up in both Roentgen (R) or Sievert (Sv) units. Some of the meters are designed with preset alarm facility. Both Digital & custom LCD analog scale with digital display models are made available. CPS & CPM modes of measurement, also have been provided in some of these models.

RADIATION MONITOR(RADMON)
TYPE : RM701

Technical Data

Radiation Monitor (RADMON) Type RM701 designed, manufactured and supplied by Nucleonix Systems is a state of art micro-controller based unit which serves as a general purpose alarming radiation survey meter.

Useful for measuring radiation levels in Reactor buildings, nuclear installations, Radio-chemical plants, reprocessing plants etc.

Additionally can be used for measuring contamination of various commodities and items in a nuclear accident scenario.

It measures dose rate in the range of 0-10R/hr/ 0-100mSv/h, in 5 linear ranges. It also measures count rate in the range of 0-99999 CPS.

It has a lot of unique features which includes user interface through a set of four command buttons & the visual indication to the user is on a large analog LCD display. Data visualization is provided on both linear analog scale & direct digital display.

Features :

- ❑ Measures gamma radiation doserate in work areas at Radiological installations and contamination of various commodities and items in a nuclear accident scenario.
- ❑ Conforms to ANSI N42.17A & CE compliant.
- ❑ Sensivity:0.01mR/hr or 0.1μSv/hr.
- ❑ Measures gamma dose rate in R/h or Sv/h.
- ❑ Dose rate accuracy of +/- 15% with Co-60.
- ❑ Overall response within +/- 20% in the energy range of 60 Kev to 1.33 Mev.
- ❑ Uses large area custom LCD display for dose rate visualization.
- ❑ Preset alarm facility for generation of audio / visual alarms.

SPECIFICATIONS

Radiation detected : X and Gamma rays

Detector : A miniature halogen quenched GM detector or its equivalent with energy compensation.

Measurement Unit : CPS / R/h / Sv/h

Measurement Range :

Option A : Dose Rate : 0–10R/h (or) (0 μSv/h–100mSv/h in 5 linear ranges) or

Option B :
(0–5R/hr) in 4 linear ranges
(0–5mR/h) (0–50mR/h)
(0–500mR/h) & (0–5R/h)

Sensitivity:0.01mR/hr or 0.1μSv/hr

Count Rate : 0–99999 CPS in 5 linear ranges.

Accuracy : Within +/-15% with Co^{60}

Range Selection : Auto

Over Range : Senses over range & shows on display.

Energy response : Within +/- 20% in the range of 60 Kev to 1.33 Mev.

Time constant : Floating time constant of 4 sec / 8 sec.

Present Alarm Range:
0–9999 CPS or
0–999.9 mR/h or 0–9999 μSv /h

Audio : Built-in piezo buzzer for generating audio chirps for radiation events and alarm O/P for preset alarms.

User Interface : FN, ON/OFF, ▲ &▼ are the four control buttons provided on the instrument. The above buttons allow the user to program and operate the instruments in appropriate manner for configuration and measurement.

Indication (Visual) : Analog bar scale visualization along with direct digital indication on custom backlit LCD display.

Power : 7.5 Volts, DC, size AA, MN1500 LR6 (5 X 1.5 Volts), Alkaline cells.

Battery Indication : Battery low indication is provided on LCD display.

Type test compliance :

a) Conforms to ANSI N42.17A performance specifications for Health Physics instrumentation (portable)

b) CE compliant

Dimensions : (a) 105 W X 195L X 50H (mm) for unit in Aluminium enclosure with power coated finish.
(b) 103 W X 205 X 38H (mm) for unit in Plastic enclosure.
(c) Carrying case : 270L x 210W x 80Ht.

Unit in powder coated metal enclosure

Unit in plastic enclosure

Meter with carrying case

RADIATION MONITOR (MICRO) TYPE : RM 703

Technical Data

RADMON (micro) Type : RM 703 with external telepole having G.M. Detector at tip is a, battery powered, hand-held, general purpose alarming radiation Survey Meter. **This portable hand held meter with 1.1 mtrs telepole with detector is highly recommended for medical cyclotron facilities to check dose rates in inaccessible areas, inside cyclotron vault at door entrance, along delivery lines in Hot cells, on the surface of vials & other high active areas.**
This product is designed around a Microcontroller Chip. It is provided with alpha Numeric LCD display for indicating the doserate in digits, dose rate as a bar graph, cumulative dose in digits. It covers wide range from 0 to 20R/hr in four ranges with auto ranging. This unit has a facility for storing the data into built-in EEPROM. The stored data can be recalled on to the display or transmitted to PC.
This unit has preset alarm facility which can be set throughout the range of the instrument.

FEATURES :

- ❑ RM703 has 1.1 mtrs telepole with detector at the tip as an optional Feature.
- ❑ Range changeover Automatic.
- ❑ Accuracy+/- 15% with Co-60.
- ❑ Facilitates storing recalling of readings and transmission of readings to PC.
- ❑ Works on 7.5V (1.5x5V) dry cell batteries.
- ❑ RTC time stamp for each reading.

SPECIFICATIONS

Detector : GM counter Type LND 713 with energy compensated filter with external pole of 1.1meter length.

Radiation detected : X & Gamma, from 60 Kev to 2 MeV.

Energy Response : Within +/- 20% from 60 KeV to 1.25 Mev

Operation Modes : CPS, CPM, Preset Time & Doserate Mode

Preset time range : 1 sec to 9999 sec
Doserate (auto ranging) :0 - 10 R/hr
Doserate TC : Low (2 sec),
Medium (4 sec),
High (8 sec)

Over Range : Unit shows over range above 10R/hr to 1000R/hr.

Range Changeover : Automatic

Accuracy : +/- 15%

Display : 16X2 alpha numeric LCD display; Digital display of dose rate and units in the first line, Bar graph or dose display in the second line.

Time Constant : Choice of three time constants LOW, MED & HI for Doserate mode.

Serial Port (optional) : Built-in RS 232 serial port for PC linking, along with data communication software cable.

Aural : Built-in buzzer provided

Data Storage : Storage of readings in built-in EEPROM. Stored Data can be recalled on to the display or transmitted to PC.

Control Buttons : START, STOP, PROG, STORE, INC & DEC are the six countrol buttons provided on the instrument. The above buttons allow the user to program & operate the instruments in appropriate manner.

Real Time Clock : On board real time clock with battery backup keeps real time information. On selecting data storage, current real time is saved along with doserate.

Power : 7.5 volts DC,size AA, MN1500 LRS (5x1.5 Volts), Alkalinec cells.

1.1 mtr telepole

Dimensions : 105W x 195L x 68Ht in mm (approx).

RADIATION DOSERATE MEASURMENT WITH RADIATION SURVEY METER (RM703) USING EXTERNAL TELEPOLE DETECTOR ARRANGEMENT

GAMMA RADIOGRAPHY SURVEY METER
TYPE : RM704

Technical Data

Gamma Radiography Survey Meter Type RM704 designed, manufactured and supplied by Nucleonix Systems is a state of art Micro-controller based unit which serves as a general purpose alarming survey meter for use in medical, agricultural, industrial & other installations where radioactive isotopes are used for a variety of applications.

This unit will be additionally used in measuring radiation levels in Reactor buildings, nuclear installations, Radio-chemical plants, reprocessing plants, etc., It measures doserate in the range of 0-50R/hr / 0-500mSv/hr in 5 linear ranges. It also measures count rate in the range of 0-99999 cps in 4 linear ranges.

It has a lot of unique features which includes user interface through a set of four commands buttons & the visual indication to the user is on a large analog LCD display. Data visualization is provided on both linear analog scale & direct digital display.

FEATURES :
- ❑ Conforms to ANSI N42.17A performance specifications for Health Physics instrumentation (portable) & CE compliant.
- ❑ Micro-controller based design.
- ❑ Compact, Elegant and light weight.
- ❑ Measures gamma dose rate in R/h or Sv/h
- ❑ Dose rate accuracy of +/- 15% with Co-60
- ❑ Overall response within +/- 20% in the energy range of 60 Kev to 1.33 Mev.
- ❑ Uses large area custom LCD display for dose rate visualization.
- ❑ Preset alarm facility for generation of audio / visual alarms.

SPECIFICATIONS

Radiation detected : X and Gamma rays

Detector : A miniature halogen quenched GM detector with energy compensating filter.

Measurement Unit : CPS / R/h / Sv/h

Measurement Range :
Dose Rate : 0mR/h–50R/h or
0µSv/h–500mSv/h in 5 linear ranges

Count Rate : 0–99999 CPS in 5 linear ranges.

Accuracy : Within +/-15% with Co^{60}

Indication (Visual) : Analog bar scale visualization along with direct digital indication on custom backlit LCD display.

Range Selection : Automatic

Over range : Senses over range & shows on display

Energy response : Within +/- 20% in the range of 60 Kev to 1.33 Mev

Time constant : Floating time constant of 4 sec / 8 sec.

Present Alarm Range: 0-999.9 mR/hr or
0 - 9999 mSv/hr or
0 - 9999 cps
Once dose-rate / count-rate exceeds these levels alarms set ON automatically.

Audio : Built-in piezo buzzer for generating audio chirps for radiation events and alarm O/P for preset alarms.

User Interface : FN, ON/OFF, ▲ &▼ are the four control buttons provided on the instrument. The above buttons allow the user to program and operate the instruments in appropriate manner for configuration and measurement.

Indication (Visual) : Analog bar scale visualization along with direct digital indication on custom backlit LCD display.

Power : 7.5 Volts, DC, size AA, MN1500 LR6 (5 X 1.5 Volts), Alkaline cells.

Battery Indication : Battery low indication is provided on LCD display.

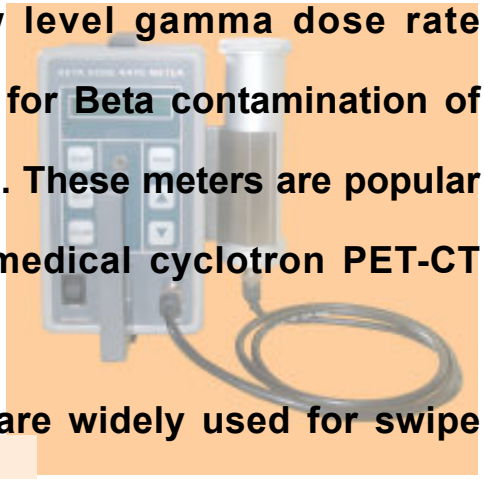
Dimensions : (a) 105 W X 195L X 50H (mm) for unit in Aluminium enclosure with power coated finish.
(b) 103 W X 205 X 38H (mm) for unit in Plastic enclosure.
(c) Carrying case : 270L x 210W x 80Ht.

Unit in powder coated metal enclosure

Unit in plastic enclosure

Meter with carrying case

BETA-GAMMA RADIATION SURVEY METERS & DIGITAL CONTAMINATION MONITORS



These meters are normally used for low level gamma dose rate measurements, swipe testing and to check for Beta contamination of hands, foot, clothing, gloves and work areas. These meters are popular with Nuclear medicine practitioners & in medical cyclotron PET-CT centres & similar other facilities.

In radiotherapy departments these meters are widely used for swipe testing of - Cobalt therapy machine jaws, - Brachytherapy source transfer tubes and LDR sources also for inspection of other sources & source housing. For swipe testing it is recommended that these meters are used in CPS or CPM modes.

Further CPS / CPM modes are selected when these meters are used for Beta contamination measurements & user has to open shutter or cover of the detector probe. For measurement of low level gamma dose rates, cover / shutter is to be kept in closed condition.

RSO using Digital Contamination Monitor for checking the Beta contamination

BETA / GAMMA RADIATION SURVEY METER
TYPE : RM707

Technical Data

Beta-Gamma Radiation Survey Meter Type RM707 designed, manufactured and supplied by Nucleonix Systems is a state of art Micro-controller based unit which serves as a general purpose alarming survey meter for use in medical, agricultural, industrial & other installations where radioactive isotopes are used for a variety of applications.
This unit will be additionally used in measuring radiation levels in Reactor buildings, nuclear installations, Radio-chemical plants, reprocessing plants, etc., It measures doserate in the range of 0-200mR/hr / 0-2mSv/hr in 4 linear ranges. It also measures count rate in the range of 0-99999 cpm in 4 linear ranges.
It has a lot of unique features which includes user interface through a set of four commands buttons & the visual indication to the user is on a large analog LCD display. Data visualization is provided on both linear analog scale & direct digital display.

FEATURES :
- ❑ Conforms to ANSI N42.17A performance specifications for Health Physics instrumentation (portable) & CE compliant.
- ❑ Micro-controller based design.
- ❑ Compact, Elegant and light weight.
- ❑ Measures gamma dose rate in mR/hr or mSv/hr
- ❑ Measures beta contamination in CPM.
- ❑ Dose rate accuracy of +/- 10% with Cs-137
- ❑ Uses large area custom LCD display for dose rate visualization.
- ❑ Preset alarm facility for generation of audio visual alarms.
- ❑ External Probe.

SPECIFICATIONS

Radiation detected : X and Gamma

Detector : A miniature halogen quenched GM detector with energy compensating filter.

Measurement Unit : CPM / R/hr / Sv/hr

Measurement Range : (Auto) Dose Rate : 0 - 200mR/hr or 0 - 2mSv/hr in 4 linear ranges Countrate : 0 - 99999 cpm in 4 linear ranges

Accuracy : Within +/-15% with Cs137

Indication (Visual) : Analog bar scale visualization along with direct digital indication on custom backlit LCD display.

Range Selection : Automatic

Over range : Sense over range and shows on display.

Energy response : Within +/- 20% in the range of 60 KeV to 1.33 MeV

Time constant : Floating time constant of 4 sec / 8 sec

Preset alarm range :
0 - 999.9 mR/hr or
0 - 9999 mSv/hr or
0 - 99999 cpm

Audio : Built-in Radial buzzer for generating audio chirps for radiation events and alarm O/P for preset alarms.

User Interface : FN, ON/OFF ▲ & ▼ are the four control buttons provided on the instrument. The above buttons allow the user to program and operate the instruments in appropriate manner for configuration and measurement.

Power : 6V, DC size AA MN1500 LR6 (4 x 1.5V) alkaline cells.

Battery indication : Battery low indication is provided on LCD display

Dimensions : 106 W X 196L X 64.5H (mm).

DIGITAL CONTAMINATION MONITOR (MICRO)
TYPE : CM 710P

Technical Data

Digital Contamination Monitor (Micro) Type CM 710P designed, manufactured and supplied by Nucleonix Systems is a state-of-art, microcontroller based unit which essentially serves as a low level alarming survey meter cum Beta contamination monitor.
It measures contamination in CPS or CPM mode and low level gamma dose rate in mR/hr / μSv/h. It has lot of unique features which include user interface, through a set of four command buttons & the visual indication to the user is on 16x2 LCD dotmatrix display module. This unit has preset alarm facility which can be set throughout the range of the instrument. Unit can store upto 1000 readings and stored data can be downloaded into PC using data communication software, through built-in RS232 serial port.

FEATURES :
- ❑ Conforms to ANSI N42.17A performance specifications for Health Physics instrumentation (portable) & CE compliant.
- ❑ Microcontroller based design.
- ❑ Compact, Elegant and light weight.
- ❑ External probe with cover for Beta / Gamma selection.
- ❑ Measures dose rate in mR/hr / mSv/h & countrate in cps / cpm.
- ❑ Accuracy +/-10% with Cs-137.
- ❑ Unit works on 7.5V, dry cells (5x1.5V).
- ❑ RTC for time stamp of each reading.

SPECIFICATIONS

Detector :
Type : Pancake GM detector
Dimension: 50mm dia
Sensitivity (Approx) : 60 cps/mR/h

Detector Probe: This consists of Pancake GM detector housed inside a cylindrical housing with handle. Probe is fixed into a side clamp on one side of the instrument. This housing is provided with cap for Beta/ Gamma selection.

Radiation detected: Beta & Gamma

Measurement Unit :
mR/h / μSv/h / cps / cpm

Measuring ranges :
(a) Dose rate : 0 - 200 mR/h (or) 0 - 2000 μSv/h
(b) Count rate : 0 - 99999 cps (or) 0 - 99999 cpm

Preset alarm range: 0 - 200 mR/h (or) 0 - 2000 mSv/h (or) 0 - 99999 cps (or) 0 - 99999 cpm.

Over range: Senses over range & shows on display.

Audio : Built-in piezo buzzer provides beeps for every detected pulse and alarm o/p for preset alarms.

Time Constant (TC): User has a choice of three TC's LO (2 sec), MED (4 sec) & HI (8 sec).

Accuracy : +/- 10% with Cs-137.

Display Indication : 16x2 backlit LCD display for showing doserate/ countrate apart from textual screens during configuration.

Data Storage : Can store upto 1000 readings. Stored data can be recalled back on to display or transmitted to PC through serial port.

Serial port / data communication: Built-in serial port facilitates data downloading into PC. Data communication software with connecting cable can be provided at extra cost.

User Interface: START, STOP, PROG, STORE, INC & DEC are the six control buttons provided on the instrument. The above buttons allow the user to program and operate the instruments in appropriate manner.

RTC: Real time stamp recorded with each reading.

Fault Diagnostics: Low battery indication is provided on the display.

Power: 7.5 Volts, DC, size AA, MN1500 LR6 (5 X 1.5 Volts), Alkaline cells

Type test compliance :
a) Conforms to ANSI N42.17A performance specifications for Health Physics instrumentation (portable)
b) CE compliant

Dimensions :
106W x 196L x 100Ht in mm (Approx.)

DIGITAL CONTAMINATION MONITOR
TYPE : CM711

Technical Data

Digital contamination monitor Type: **CM711**designed, manufactured and supplied by Nucleonix Systems is a state of art micro-controller based unit which serves as a **general purpose alarming radiation survey and contamination monitor** for use in medical, industrial & other installations where radioactive isotopes are used for a variety of applications. This meter is highly recommended for use in Nuclear medicine centres, PET-CT centres etc.

This unit is offered with an external probe housing a end window / pancake GM detector. It measures dose rate the range of 0 - 99.99mR/h in 4 linear ranges & countrate in the range of 0 - 99999 CPM in 4 linear ranges.

It has a lot of unique features which includes user interface through a set of four command buttons & the visual indication to the user is on a large analog LCD display . Data visualization is provided on both linear analog scale & direct digital display.

FEATURES :

- ❑ Micro-controller based design.
- ❑ Compact, Elegant and light weight.
- ❑ Measures gamma dose rate in R/h or Sv/h
- ❑ Measure beta contamination in CPM.
- ❑ Dose rate accuracy of +/- 10% with Cs-137
- ❑ Uses large area custom LCD display for dose rate visualization.
- ❑ Preset alarm facility for generation of audio visual alarms.

Unit in plastic enclosure

Meter with carrying case

SPECIFICATIONS

Radiation detected : Alpha, Beta and Gamma rays

Detector : Pancake GM detector type GM138 or equivalent

Detector Probe: This consists of GM detector fixed inside a housing with removable cover for Beta measurement. Probe is fixed onto a side clamp on one side of the instrument.

Measurement Unit : CPM / R/h / Sv/h

Measurement Range :
Dose Rate :0 –99.99 mR/h (or)
0 - 999.9 μSv/h in 4 linear ranges

Count Rate : 0- 99999 CPM in 4 linear ranges.

Range Selection : Manual

Over range : Senses over range & shows on display.

Accuracy : Within +/-10% with Cs^{137}

Time constant : Floating time constant of 4 sec / 8 sec.

Present Alarm Range:
0-9999 CPM (or)
0.00 - 99.99 mR/h (or)
0.0 - 999.9 μSv/h

Audio : Built-in piezo buzzer for generating audio chirps for radiation events and alarm O/P for preset alarms.

User Interface : FN, RANGE, ▲ &▼are the four control buttons provided on the instrument. The above buttons allow the user to program and operate the instruments in appropriate manner for configuration and measurement.

Indication (Visual) : Analog bar scale visualization along with direct digital indication on custom backlit LCD display.

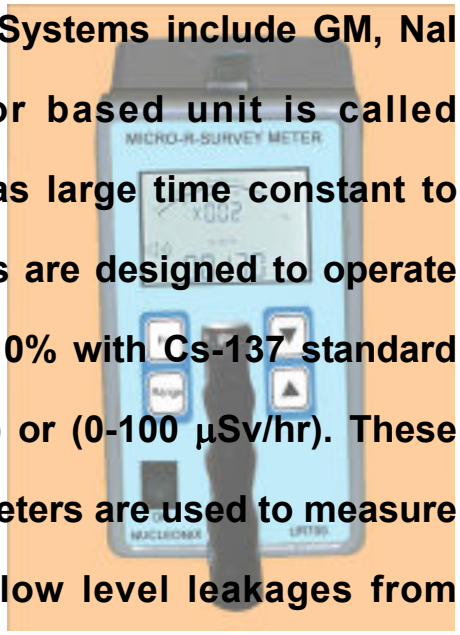
Power : 7.5 Volts, DC, size AA, MN1500 LR6 (5 X 1.5 Volts), Alkaline cells.

Battery Indication : Battery low indication is provided on LCD display.

Battery life : > 50 hrs.

Dimensions :
(a) 105 W X 195L X 50H (mm) for unit in Aluminium enclosure with power coated finish.
(b) 103 W X 205 X 38H (mm) for unit in Aluminium enclosure with power coated finish.
(c) Carrying case : 270L x 210W x 80Ht.

VERY LOW LEVEL SURVEY METERS



Micro-R-Survey Meters offered by Nucleonix Systems include GM, Nal & Plastic Scintillator based. GM Detector based unit is called 'Environmental Radiation Survey Meter' & has large time constant to record measurement. Majority of these meters are designed to operate in pulsed mode & calibration accuracy of + 10% with Cs-137 standard is achieved. Range offered is (0 to 10 mR/hr) or (0-100 μSv/hr). These meters are rugged in construction. All these meters are used to measure very low level gamma dose rates, may be low level leakages from therapy machines or Radiation Shieldings, or source holders etc.

MICRO-R-SURVEY METER
TYPE : UR 705

Technical Data

Micro-R Survey Meter Type: UR 705 manufactured by NUCLEONIX SYSTEMS is primarily designed to measure low level Gamma and X-radiation. This Portable Survey Meter, designed around integrally coupled 1" x 1" NaI (Tl) Scintillator to a 1 1/2" PMT, will offer an optimum performance in counting Low-Level Gamma Radiation dose rate.

This unit can measure and display dose rates in the range of 0-10000 mR/hr on a dot matrix LCD Display. Dose rates close to natural background levels can be measured accurately.

This unit is ideally suitable for Radiometric and Environmental Radiation Monitoring involving low-level radiation dose rates.

This unit employs microcontroller based design and has number of unique features. User can store upto 1000 readings at the press of a button and can recall back, for visual indication on a dot matrix LCD display. This unit is provided with a built-in RS232 port (optionally) through which the stored data can be down loaded into PC.

FEATURES :

- ❑ Microcontroller based design
- ❑ Conforms to ANSI N42.17A performance specifications for Health Physics instrumentation (portable) & CE compliant.
- ❑ Microcontroller based design.
- ❑ Compact, elegant and light weight.
- ❑ User can store upto 1000 readings
- ❑ Detects Gamma and X radiation
- ❑ Measures dose rate from 0-10000 mR/hr High Range (or) 0.01 to 99.99 mSv/hr
- ❑ Detector : 1" x 1" x 1 1/2" NaI (Tl) Detector probe assembly is built into the instrument enclosure box
- ❑ RS 232 serial port (Optional)
- ❑ Built in audio
- ❑ Works on 6V DC dry cells

SPECIFICATIONS

Detector :
(a) NaI (Tl) Scintillator, 1"d x1"h coupled to a Photomultiplier Tube. Detector assembly is inside the survey meter enclosure.
(b) External unit through 1mtr cable.

Calibration Accuracy :
(a) Better than +/-10% (specified with a Cs-137 standard source) from 100 μR/hr onwards.
(b) within +/-20% upto 10000 mR/hr

Acquisition mode:
CPS : 0-50000
CPM : 0-5000

Dose Rate (mode):
1-10000 μR/hr or
0.01-100.00 μSv/hr

Over Range : This instrument will show over range above the 10,000μR/hr

Data Storage : Can store upto 1000 data readings. Stored data can be recalled back on to display.

Display Indication: Dot Matrix LCD display for dose rate / cum dose.

Sensitivity: 1 μR/hr or 0.01mSv/hr

Serial Port (optional) : Built-in serial port facilitates data down loading into PC. Data Communication Software with connecting cable can be provided at extra cost as an additional option.

User Interface :START, STOP, PROG, STORE, INC, DEC, POWER ON command buttons for setting of parameters & operation of the instrument.

Power : 6 volts DC, BPL Excell or DURACELL ULTRA, Size AA, MN1500 LR6 (4 X 1.5 Volts), Alkaline cells.

Dimensions : 106W x 196L x 95Ht in mm (Approx.)

Weight : Unit with detector (1"x1" NaI) : 2kg

MICRO-R-SURVEY METER
TYPE : UR709

Technical Data

Micro-R Survey Meter Type : **UR709** manufactured by NUCLEONIX SYSTEMS is primarily designed to measure low level Gamma and X-radiation. This Portable Survey Meter, designed around integrally coupled 1"x1" NaI (TI) scintillation to a 1"x1.5" PMT will offer an optimum performance in measuring Low-Level Gamma Radiation dose rate.

This unit can measure and display dose rates in the range of 0-10 mR/hr in 5 ranges on a custom LCD Display both digitally as well on analog segment display. Dose rates close to natural background levels can be measured accurately. This unit is ideally suitable for Radiometric and Environmental Radiation Monitoring involving low-level radiation dose rates. This unit measures signal in current mode the pulse O/P from the detector facilitating measurement of 1"x1" NaI (TI) scintillation to a 1"x1.5" PMT.

FEATURES :

- Conforms to ANSI N42.17A performance specifications for Health Physics instrumentation (portable) & CE compliant.
- Microcontroller based design
- Compact, elegant and light weight
- Detects Gamma and X radiation
- Measures dose rate from 0-10 mR/hr in 5 linear ranges
- Detector : 1"x1" NaI (TI) scintillation to a 1"x1.5" PMT
- Uses special custom LCD display for direct display digitally as well as analog value in the corresponding range of measurement.
- Works on 6V DC dry cells

SPECIFICATIONS

Radiation detected :
X and Gamma rays

Detector: 1"x1" NaI (TI) scintillation to a 1"x1.5" PMT

Measurement Unit :
CPS / R/hr / Sv/hr

Measurement Range
Doserate : 0-10mR/hr or 0-100μSv/hr in 5 linear ranges
Countrate: 0 - 99999 cps in 4 linear ranges

Accuracy : Within +/- 10% with Cs-137

Indication (Visual): Analog bar scale visualization along with direct digital indication on custom backlit LCD display.

Range Selection : Automatic

Over range : Sense over range and shows on display.

Energy response: 1"x1" NaI (TI) scintillation to a 1"x1.5" PMT in the range of 60 KeV to 1.33 MeV

Time constant : 8 sec

Audio : Built-in piezo buzzer for generating audio chirps for radiation events and alarm O/P for preset alarms.

User Interface : FN ON/OFF, p & q are the four control buttons provided on the instrument. The above buttons allow the user to program and operate the instruments in appropriate manner for configuration and measurement.

Power : 6V, DC size AA MN1500 LR6 (4 x 1.5V) alkaline cells.

Battery indication : Battery low indication is provided on LCD display

Dimensions : 106 W x 196L x 100H (mm)

AREA GAMMA MONITORS

Area Gamma Monitors are normally installed at different locations nearer to therapy machines such as Cobalt, and Brachytherapy unit & similar other machines. These are also installed in medical cyclotron facilities in different labs. These Area gamma monitors in different ranges are used to monitor & display gamma dose rates & produce audio visual alarms once the dose rate levels exceed preset limits. We have optimized designs of gamma area monitors exclusively to meet the requirements for installations in Radiotherapy departments, Medical cyclotron facilites and such other similar facilities.

Area Gamma Monitors in installed condition in a medical cyclotron facility

AREA GAMMA MONITOR
TYPE : GA720H

Technical Data

FEATURES :

- ❑ Performance specifications confirm to ANSI N42.17A
- ❑ Primarily serves as a Gamma Zone monitor, for cobalt therapy & Brachytherapy machines, also recommended for installation at different locations in a medical cyclotron facility.
- ❑ Provided with an external detector probe (length from 1 meter / 10 meters or more).
- ❑ Facilitates networking of multiple Area monitors for centralized monitoring of doserate & alarm status through software.
- ❑ Calibration accuracy within +/- 10% with Cesium source.
- ❑ Energy response within +/-20% from 100keV upto 1.25MeV.
- ❑ Dose rate range covered (0.1 - 100) mR/hr.
- ❑ Auto ranging & auto TC selection in the range of 16 sec to 0.5 sec depending upon dose rate.
- ❑ Large size 4x7 segment LED indication for dose rate is provided.
- ❑ Designed using Energy compensated GM tube.
- ❑ Large size WINDOWS for NORMAL & ACTIVE alarm condition.
- ❑ 16x2 LCD dotmatrix display for visualization of other parameters.

Gamma Area Monitor type GA 720H, designed & manufactured by NUCLEONIX SYSTEMS is primarily meant to serve as a Gamma Zone Monitor to indicate dose rates and alarm status (visual and aural), once the dose rates exceed the preset level fixed by the user. Also relays will be activated on alarm condition. Unit also indicates fault diagnostic conditions on 1/2" LED display.

Unit is provided always with an external detector probe mounted on the top of Area gamma monitor enclosure by a clamp, with a short cable of 1 meter length by default. Longer cable lengths can be provided on request.

This unit will be useful for monitoring Gamma dose rate levels in working areas of radioisotope laboratories, in oncology departments near cobalt therapy machines or Brachytherapy machines or at other similar medical systems & also in a medical cyclotron facility, or at other medical & industrial radiological installations.

This unit indicates the dose rate digitally on a 4 x 7 segment LED display. Each of the annunciator windows for NORMAL and ACTIVE conditions has LED array. Once alarm triggers ACTIVE window starts blinking.

Unit can be programmed / configured using front panel keypad which can be deactivated after completion of programming. Configuring the unit namely setting preset level, setting reset mode - AUTO/MANUAL etc are achieved by this keypad.

Unit also performs self-diagnostics for HV failure, pulse processing electronics failure and detectors failure on power up.

Alarm acknowledge and reset pins are provided on the circular I/O connector for remote acknowledge & reset.

SPECIFICATIONS

Radiation detected :
X – ray & Gamma Radiation

Range : 0.1 mR/hr to 100 mR/hr

Detector : Halogen quenched energy compensated GM tube.

Calibration Accuracy : +/-10% throughtout the range.

Display : Auto – ranging direct reading, 4 digit 7 segment LED display & 16x2 LCD display. 4 x 7 segment display is interfaced using multiplexed display driver IC & used for display of dose-rate information. 16x2 LCD for visualization of preset alarm & other parameters.

Time Constant : Time constant varies continuously from 16 sec to 0.5 sec depending upon countrate.

Alarm range :
0.1 mR/hr to 99.9 mR/hr. Alarm setting accuracy, calibration stability.
Better than +/-10% over a period of six months.

Alarm System :
a. Alarm indication is by flashing Red (LED) large area window display and Loud audio alarm.
b. Distinctive EHT / Detector failure alarm.
c. The instrument has alarm acknowledgement and Reset switches on front panel.
d. Provision for remote alarm acknowledge and reset.
e. Alarm annunciation scheme: as tabulated below.

Parameter Status	Visual indication (Red LED)	Audio
Normal	OFF	OFF
Abnormal	Flashing	ON
On ACK	Steady Red	OFF
Back to normal	Steady Red	OFF
Reset on abnormal	Steady Red	OFF
Reset on normal	OFF	OFF

Monitor Enclosure :
Vapour-tight, rugged & elegant. The instrument can be offered with compliance to required IP standards.

Mounting :
Monitor is wall-mountable type.

DC output : +12V DC at 1A ; -12V at 1A, +24V DC at 0.5A; -24V at 0.5A, 48watts maximum output
Regulation : Better than +/-0.1%

Noise and ripple : Less than 3mv peak to peak as observed at the power supply output connector level.

Voltage adjustments : +/- 5% minimum range

Circuit protection : Input AC lines fused. Output is protected against short circuit and power supply recovers fully on removing the short circuit.

Application : This is essentially used as part of minim based gamma ray spectrometer GR611M.

Optional Accessories / Additionally Features (at extra cost) :
i. Detector probe to measuring unit cable lengths, 5,10,15&20 meters can be provided on request.
ii. (4-20) mA current loop output.
iii. Relay contacts through circular I/O connector for external control & use.
iv. RS485 output for networking & data communication.
v. Networking software (Net count).

Picture shows Area Gamma Monitor Type GA720 in Installed condition, adjacent to Cobalt therapy machine

WIDE RANGE AREA MONITOR
TYPE : WR725A

Technical Data

FEATURES :

- Performance specifications confirm to ANSI N42.17A
- EMI/EMC compliance as per IEC 61000.
- Instrument enclosure and detector assembly are IP-54 compliant.
- Radiation tolerant upto 10^4 Rad.
- Firmware tested based on IEEE std : 1012.
- Microcontroller based design has been employed
- Dose rate range covered (0.1 to 200 mR/hr) by low range detector & (200 mR/hr to 20 R/hr) by high range detector.
- Auto ranging & auto TC selection in the range of 16 sec to 0.5 sec depending upon dose rate
- Large size 4x7 segment LED indication for dose rate is provided
- Designed using two GM tubes type GM130E & GM136E.
- Large size WINDOWS for NORMAL & ACTIVE alarm condition
- 4 to 20 mA current loop output is available for remote indication on a I/O connector (optional)
- 16x2 LCD display dotmatrix display for visualization & other parameters.

Wide Range Area Monitor type WR725A, manufactured by NUCLEONIX SYSTEMS employs state-of-art micro-controller based design and is primarily meant to serve as a Gamma Zone Monitor to indicate dose rates and gives audio, visual alarms once the dose rates exceed the preset level fixed by the user. Additionally relay contacts will be activated on alarm condition.

This unit will be useful for monitoring Gamma dose rate levels in working areas of Radiochemical plants / Reprocessing plants waste immobilization plants & other similar radiological installations.

This unit indicates the dose rate digitally on a 4 x 7 segment LED display. Each of the annunciator windows for NORMAL and ACTIVE conditions has LED array. Once alarm triggers ACTIVE window starts blinking.

Unit can be programmed / configured using front panel keypad which can be deactivated after completion of programming. Configuring the unit namely setting preset level, setting reset mode - AUTO/MANUAL etc are achieved by this keypad.

Unit also performs self-diagnostics for EHT failure, pulse processing electronics failure & detectors failure on power up.

Alarm acknowledge and reset pins are provided on the circular I/O connector for remote acknowledge & reset.

APPLICATIONS :

1. This Area monitor is recommended for unit in Radiological installation, Nuclear medicine departments, PET-CT centres, I-131 therapy wards, medical cyclotron facilities & Radiotherapy departments etc.
2. It is also recommended in Nuclear installations, waste immobilization plants Nuclear power plants & other similar Radiological installations.

SPECIFICATIONS

Radiation to be detected : X -ray & Gamma Radiation.

Range : 0.1 mR/hr to 20.00 R/hr
1μSv/hr to 200.0 mSv/hr
Unit is configurable
Range selection is automatic

Detector probe : Energy compensated Halogen quenched G.M.
Tubes GM7130E or equ. for low range and GM136E or equ. for high range both detectors with biasing HV are mounted in a SS probe.

Energy Dependence: Within +/- 18% of true dose rate from 100 keV to 1.3 MeV gammas..

Accuracy : +/ - 10% Full Scale

EHT: 400 V to 700 V DC adjustable (Typical 500V)

Display : Auto-ranging direct reading, 4 digit 7 segment LED display and 16x2 LCD display. 4x7 segment display is used for display of dose-rate information and hardware status information & 16x2 LCD display is used for visualization of preset alarm and other parameters.

Overload : Senses overload above 200% of fullscale and upto 1000R/h & indicates on display "OL"

Over-range : Senses if the radiation field being measured has exceeded the measurement range of the instrument and upto 200% of the instrument and displays "OFl"

Recorder output : 4 to 20 mA, with 600 ohm load.

Recorder output stability :

a) Non-linearity : Max = 0.025% of Span
b) Offset current (Io=4mA) : Max = 0.0005% of Span / °C
c) Span Error (Io=20mA) : Max = 0.005% of Span / °C

Time Constant : First reading on Power ON within 5 secs.

Normal (Slow) **:** 30 sec to 0.5 sec automatically varying inversely with the radiation level.

Abrupt detection**:** Update the current reading within 2 sec and return to normal mode.2.13

Calibration Accuracy : +/- 10% through out the range.

Instrument "ON" Indication : Large Area Green LED Lamp. This will indicate the Normal condition also.

Alarm range : 0.1 mR/hr to 19.99 mR/hr (1 μSv/hr to 199.9 mSv/hr)
The alarm level setting will be carried out through front panel keypad / handheld configurator / PC. Front panel keypad is provided with DIP switch de-activation

Alarm Indication :

a) RED (LED) flashing large area window display
b) Loud audio tone (dual frequency tone)

Alarm annunciation scheme : As tabulated below

Parameter Status	Visual indication (Red LED)	Audio
Normal	OFF	OFF
Abnormal	Flashing	ON
On ACK	Steady Red	OFF
Back to normal	Steady Red	OFF
Reset on abnormal	Steady Red	OFF
Reset on normal	OFF	OFF

Instrument Controls:

a) Acknowledgement switch for muting audio
b) Reset switch for resetting the Alarm indication and alarm relay.
c) Power ON/OFF switch (This is inside the cabinet) with Power ON indication

Instrument Fault indication:

a) EHT failure: Visual alarm with flashing RED LED indication & "Eht" message on display
b) Detector failure: Visual alarm with flashing red LED & "d-FL" message on display.
c) Microprocessor / microcontroller failure: Visual alarm with flashing green lamp.
d) Fault indications are cleared automatically if normal status is resumed.

Detector Housing:

a) The G. M. Detector will be located external to the Monitor.
b) It is housed in a suitable, air-tight SS shell with built-in pre-amplifier to drive upto 50 mtrs long cable.
c) The instrument will be provided with 10 mtr cable between detector and the monitor.
d) The detector housing will qualify minimum industrial protection Class IP-54.
e) The monitor has a clamp on the top for fixing the detector assembly.
f) Provision to connect the detector with short cable also will be available.
g) A separate bracket for wall mounting of detector housing will be provided.

Monitor Enclosure:

a) Vapor-tight, rugged & elegant.
b) The door is provided with lock and key arrangement
c) The enclosure is designed to qualify minimum industrial protection Class IP-54.
d) Decorative with visual aesthetics, prominent alarm display and good readability.

Mounting : Detector housing is mounted using clamps on top of the monitor.
The monitor is wall mountable type. Brackets for the monitor & detector housing will be supplied along with the equipment.

Remote /External Console :

a) 4 - 20 mA linear proportional to full scale display output. Current output will be able to drive load of 600 ohms. Output circuitry will be able to drive 200 mtrs.of twisted pair of wires.
b) Two sets of potential free contacts of Alarm relay (Change over). Contact rating 3 Amp at 250 VAC. The relay is energized on normal condition and de-energised under alarm condition.
c) Remote alarm acknowledgement and reset signals for the field instruments (Normally open contact).
d) Indication of instrument fault condition (detector, EHT & LV supplies failure), overflow & overload condition by up-scale 4-20 mA. (22.5 mA).
e) All these signals are terminated on a 17 pin socket (Allied Connectors). The corresponding mating plug with 5 mtr cable will be supplied with the monitor.
f) RJ45 connector for Ethernet port
g) RS-485 serial port (optional). This is provided, on a pair of D-type connectors (male & female).

Computer Interface :
The monitor shall have a Ethernet 10/100 Mbps port for interfacing with a remote IBM PC-compatible computer. The features supported by Ethernet port are given below.

- The PC and the monitor shall operate in a host-slave configuration and the software protocol will be MODBUS/TCP.
- The PC as the host shall give commands and send queries. The monitor will carry out various functions in response to the queries.
- The firmware of the monitor shall be able to send the instrument data like instrument ID, instrument type, input range, display range, alarm settings, alarm status, current reading, diagnostic status of EHT/GM tube etc. to the Host PC on demand.
- The firmware shall be able to receive commands from Host PC and carry out the setting of different parameters like instrument ID, instrument type, input range, display range, alarm settings, Ack, Reset, instrument address etc.

RS485 (Optional)
The monitor will have a RS485 port for interfacing with a remote IBM PC-compatible computer. The features supported by RS485 port are given below.

a) The PC and the monitor will operate in a host-slave configuration and the software protocol will be RS485 port.
b) The PC as the host will give commands and send queries. The monitor will carry out various functions in response to the queries.
c) The firmware of the monitor will be able to send the instrument data like instrument ID, instrument type, input range, display range, alarm settings, alarm status, current reading, diagnostic status of EHT/GM tube etc. to the Host PC on demand.
d) The firmware will be able to receive commands from Host PC and carry out the setting of different parameters like instrument ID, instrument type, input range, display range, alarm settings, Ack, Reset, instrument address etc.

Self Diagnostics : The monitor will have built-in self diagnostics. On being powered it will perform tests to ensure that all components and sub systems are functioning properly. It will check for the Power supply, High Voltage Supply, Detector and pulse processing electronics.

I**nput Power :** 230VAC +/-10%, 50Hz , single phase supply. Power ON/OFF switch will be provided with a neon indicator. Spike suppressor and line filter are also provided.

Environment : The instrument will be able to withstand temperature upto 50 deg C and relative humidity upto 90% in radiation areas.
The instrument enclosure and detector assembly will comply with IP-54. Electronic units will with stand cumulative radiation dose of 10000 Rad. (30 years of operation).

Mechanical Enclosure :
Size : 357H x 380W x 140D,
Weight : 8.5kg approx

Instrument Trolley : (offered separately)
A suitable stand for fixing area monitor will be supplied optionally. This will be made of MS and will be provided with brackets for mounting the instrument. This stand will be designed to confirm to Seismic tests. One mains supply board with required sockets, indicators and switches will be provided. One mains supply board with required sockets, indicators and switches / MCBs will be provided on the trolley.

Options :
(1) 16 bit resolution current loop (4-20mA) instead of 14 bit resolution.
(2) Log scale O/P for 4-20mA instead of 4-20 linear O/P
(3) 3.5" QVGA color TFT display in lieu of 7 segment LED & 16x2 LCD display.
(4) RS485 serial interface.

VENTILATION DUCT RADIATION MONITOR
TYPE : GA 721
(0.1 mR/hr to 600 mR/hr)

Technical Data

FEATURES :

- Microcontroller based design has been employed
- Dose rate range covered (0.1 - 600) mR/hr in two ranges
- Auto ranging & auto TC selection in the range of 16 sec to 0.5 sec depending upon dose rate
- Large size 4x7 segment LED indication for dose rate is provided
- Designed LND GM tube type 71313
- Large size WINDOWS for NORMAL & ACTIVE alarm condition
- 4 to 20 mA current loop / 0-5V analog is available for remote indication on a I/O connector (optional)
- 16x2 LCD display dotmatrix display for visualization & other parameters.

GA721 manufactured by NUCLEONIX SYSTEMS employs state-of-art micro-controller based design and is primarily meant to serve as a Ventilation Duct Radiation Monitor to indicate dose rates and give alarm, visual and aural, once the dose rates exceed the preset level fixed by the user. Also relays will be activated on alarm.

This unit will be useful for **monitoring gross gamma activity in the exhaust air duct of Reactor building/Service building/ Cyclotron facility Ventilation System** and to give activity level signal output to Local as well as control room. The unit consists of (a) Detector assembly and (b) monitor unit. The Detector assembly will be in a Lead Castle close to duct and away from the monitor unit and is connected by means of a signal / EHT cable of about 10 meter length.

This unit indicates the dose rate digitally on a 4 x 7 segment LED display. Unit has additionally 16x2 LCD dot-matrix display which indicates fault dignostic info & preset level & other configuration parameters. Each of the annunciator windows for NORMAL and ACTIVE conditions has LED array. Once alarm triggers ACTIVE window starts blinking.

Unit can be programmed / configured using front panel keypad which can be deactivated after completion of programming. Configuring the unit namely setting preset level, setting reset mode - AUTO/MANUAL etc are achieved by this keypad.

Unit also performs self-diagnostics for EHT failure, pulse processing electronics failure & detectors failure on power up.

Alarm acknowledge and reset pins are provided on the circular I/O connector for remote acknowledge & reset. RS485 port is also available optionally.

APPLICATIONS :

1. This Area monitor is recommended for unit in Radiological installation, Nuclear medicine departments, PET-CT centres, I-131 therapy wards, medical cyclotron facilities & Radiotherapy departments etc.
2. It is also recommended in Nuclear installations, waste immobilization plants Nuclear power plants & other similar Radiological installations.

Recorder output stability :
a) Non-linearity : Max = 0.025% of Span
b) Offset current (Io=4mA) : Max = 0.0005% of Span / °C
c) Span Error (Io=20mA) : Max = 0.005% of Span / °C

Time Constant : First reading on Power ON within 5 secs.
Normal (Slow) : 30 sec to 0.5 sec automatically varying inversely with the radiation level (Count rate).
Abrupt detection : Update the current reading within 2 sec and return to normal mode.

Calibration Accuracy : +/- 10% through out the range.

Instrument "ON" Indication : Large Area Green LED Lamp. This will indicate the Normal condition also.

Alarm range : 1 mR/hr to 99 R/Hr (10 μSv/Hr to 999 mSv/Hr)
Range Extendable to 999 R/hr
The alarm level setting will be carried out through front panel keypad / RS485 port using handheld configurator / PC with password protection. Front panel keypad is provided with DIP switch de-activation

Alarm Indication :
a) Red (LED) flashing large area window display
b) Loud audio tone (dual frequency tone)

Alarm annunciation scheme : As tabulated below

Parameter Status	Visual indication (Red LED)	Audio
Normal	OFF	OFF
Abnormal	Flashing	ON
On ACK	Steady Red	OFF
Back to normal	Steady Red	OFF
Reset on abnormal	Steady Red	OFF
Reset on normal	OFF	OFF

Instrument Controls :
a) Acknowledgement switch for muting audio
b) Reset switch for resetting the Alarm indication and alarm relay.
c) Power ON/OFF switch (This is inside the cabinet) with Power ON indication.

Instrument Fault indication :
a) EHT failure: Visual alarm with flashing red LED indication & "Eht" message on display
b) Detector failure: Visual alarm with flashing red LED & "d-FL" message on display.
c) Microprocessor / microcontroller failure: Visual alarm with flashing green lamp.
d) Fault indications shall be cleared automatically if normal status is resumed.

Detector Housing :
- The Pressurized Ion Chamber is located external to the Monitor.
- It is housed in a suitable, air-tight **SS** shell and is connected to the Electronic Unit through a suitable Cable assembly (Length could be extended upto a maximum of 50 mtrs)
- The instrument is provided with 20 mtr cable between detector and the monitor.
- The detector housing will qualify minimum industrial protection Class IP-54.
- A separate bracket for wall mounting of the detector housing will be provided.

Monitor Enclosure :
- Vapour-tight, rugged & elegant.
- The door is provided with lock and key arrangement
- The enclosure shall qualify minimum industrial protection Class IP-54.
- Decorative with visual aesthetics, prominent alarm display and good readability.

Mounting: Detector housing is mounted using clamps on top of the monitor. The monitor is wall mountable type. Brackets for the monitor & detector housing shall be supplied along with the equipment.

Remote /External Console :
- 4 - 20 mA linear proportional to full scale display output. Current output will be able to drive load of 600 ohms. (Output circuitry shall be able to drive 200 mtrs.of twisted pair of wires).
- Two sets of potential free contacts of Alarm relay (Change over). Contact rating 3 Amp at 250 VAC. The relay shall be energized on normal condition and de-energised under alarm condition.
- Remote alarm acknowledgement and reset signals for the field instruments (Normally open contact).
- Indication of instrument fault condition (detector, EHT and LV supplies), over range & overload conditions by up-scale 4-20 mA. (22.5 mA).
- All these signals shall be terminated on a 17 pin socket (Allied Connectors). The corresponding mating plug with 5 mtr cable shall be supplied with the monitor.
- RS-485 serial / Ethernet port. This shall be in parallel with D-type connectors.

Computer interface : The monitor shall have a RS-485 Serial/ Ethernet Communication port for interfacing with a remote IBM PC-compatible computer. The features supported by Ethernet port are given below.
- The PC and the monitor shall operate in a host-slave configuration and the software protocol will be MODBUS-RTU / MODUB-TCP.
- The PC as the host shall give commands and send queries. The monitor will carry out various functions in response to the queries.
- The firmware of the monitor shall be able to send the instrument data like instrument ID, instrument type, input range, display range, alarm settings, alarm status, current reading, diagnostic status of EHT/GM tube etc. to the Host PC on demand.
- The firmware shall be able to receive commands from Host PC and carry out the setting of different parameters like instrument ID, instrument type, input range, display range, alarm settings, Ack, Reset, instrument address etc.

NETWROKING SOFTWARE (GAMMA LINK)

This networking software - Gamma Link facilitates visualization & monitoring of dose rate, alarm status & fault diagnostic information of various Area Gamma monitors located in different labs in a Medical Cyclotron facility. Usually this networking software is installed in a personal computer situated in centralized control room.

Software for Radiation Monitoring Network Grid (RadGrid)

INTRODUCTION:

RadGrid is a comprehensive and user friendly software that will configure, communicate and continuously monitor various Radiation Monitoring instruments manufactured by Nucleonix using MODBUS RTU and TCP protocols. It will optionally update instrument Alarm condition and status in Remote database and Nucleonix Instrument Grid database (Optional). The software runs on Windows 7 Operating system.

Parameters that are read from the instruments include Measured value, Preset value, Hardware status like LV supply, EHT status, Counts, Alarm status and other fault diagnostic information. Upto 2000 instruments of which 255 MODBUS RTU instruments (max) can be connected to RadGrid.

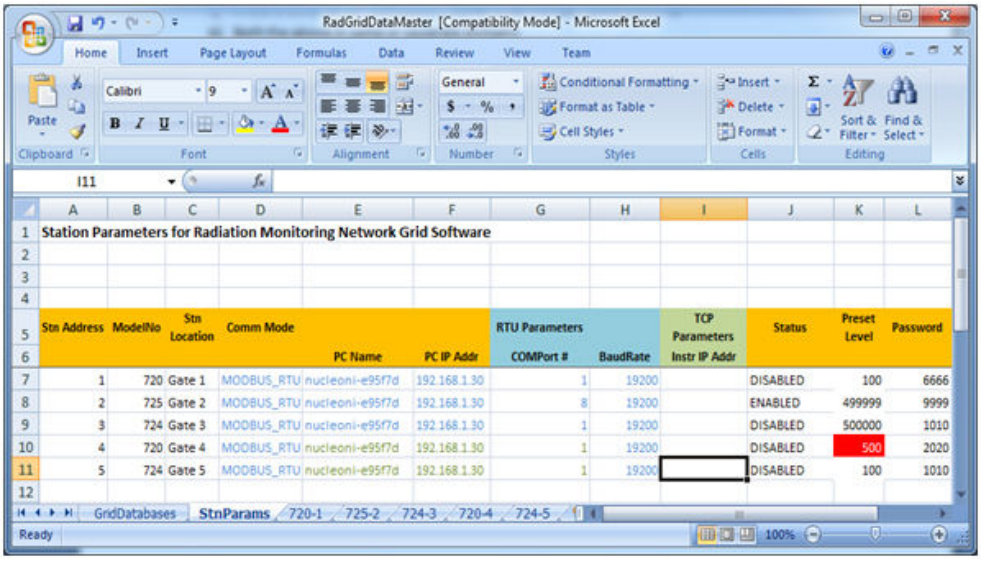
GRID CONFIGURATIONS:

A typical Grid configuration could contain:

i. Area Gamma Monitors (AGMs) of various types, Continuous Air Monitors (CAMs) of various types connected by MODBUS RTU to one or more PCs,
ii. HFs and other Ethernet based instruments connected by MODBUS TCP
iii. Both the above in same or separate domains
iv. Users in the above Network domains, who need to access the data and diagnostic info from the above PCs through RadGrid software
v. Users in different locations, who would like to access the Grid data from Internet
vi. NSPL Tech team who would like to monitor the Health of the Grid from Internet

CONFIGURATION OF INSTRUMENTS GRID :

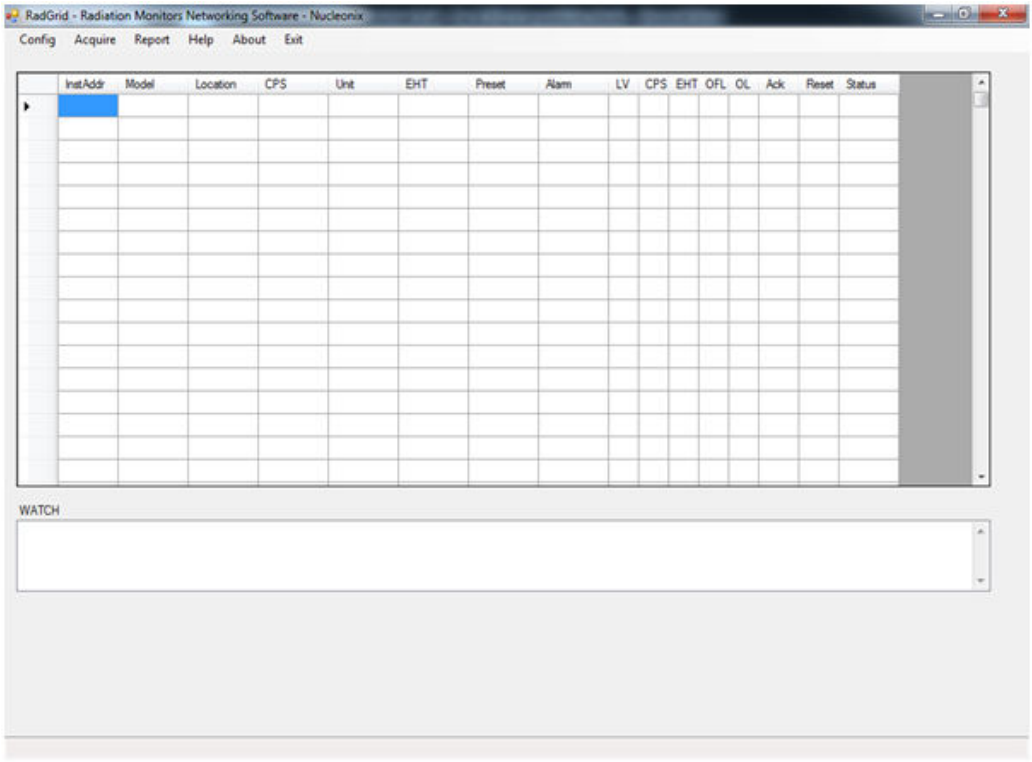
- The Configuration parameters for all instruments are stored in a password protected Excel file. It contains details like StnAddr, ModelNo, Stn Location, Comm Mode, PC Name, PC IP Address, RTU Params – ComPort# & Baud rate, TCP Params – Intr IP Addr & TCP Port#, Status, Preset Level, Password, etc.
- All that the User needs to do is to enter the appropriate configuration parameters for various Instruments.
- The screen below shows typical values.



- The Software has strong Validation and authentication features built into it. This means that if inappropriate data is entered, then validation will fail and Acquisition will not start until proper data is entered or that particular instrument is disabled.
- Config can also be used to Add/Enable/Disable/Remove an instrument from Grid, change parameters of an instrument. For changes to take effect, Acquisition must be stopped and Started again. However, Config file can be opened and edited while acquisition is on.

MAIN SCREEN :

- The main screen of RadGrid looks like below.
- The top row shows the Menu, which has Config, Acquire, Report, Help, About and Exit functions.
- It has a DataGrid that shows data from various instruments along with Diagnostic information.

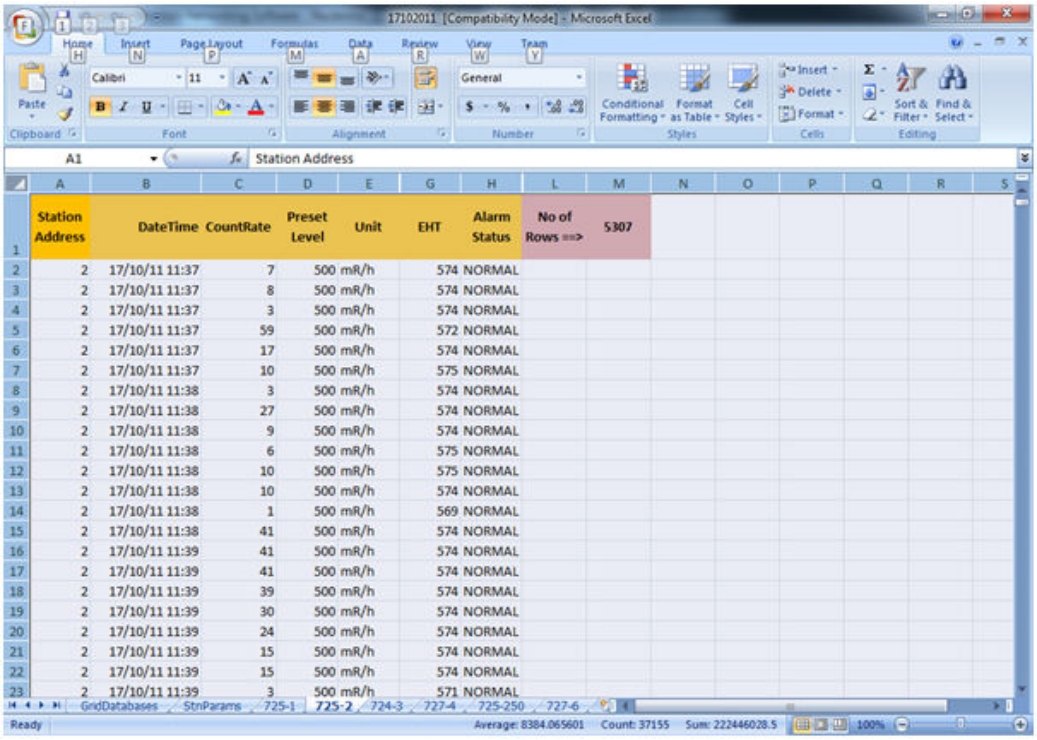


ACQUIRE :

- Clicking on Start in Acquire menu will start the acquisition.
- Validation and Authentication is done before acquisition is started.
- Acquire will start monitoring instruments as per Configuration parameters for ENABLED devices.
- RED or GREEN indications as per the read Status bits in the Grid.
- Data is written to Excel after every read. Optionally, it can write to remote database and Nucleonix's Instrument Grid Database.
- The Filename is set to Current day.

REPORT :

- A snapshot of data is created till current Time and opened for user to see.
- Report formats can be configured differently for various instruments.
- A sample report is shown below:



HELP :

- Help videos can be played by clicking on this menu.
- Help videos clearly explain the functioning of software, making connections, trouble shooting, and other features. This will enable the user to operate the software with utmost ease.

PERSONNEL MONITORING INSTRUMENTATION

A. POCKET DOSIMETERS :

Nucleonix systems offers Indigenously developed Si-diode detector based digital pocket dosimeter (with alarm facility) having excellent features. There are two models, one Pocket worn sleek model and the second, waist belt worn type. Both dose rate and cumulative dose are stored, in the unit.

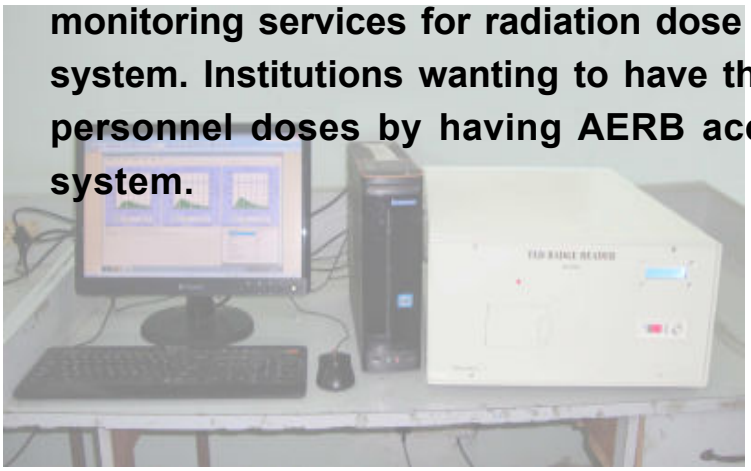
Dose records data management software, provided for one of the models with Docking station is an excellent choice for institutional users who may like to have data base of dose records of the personnel working in their institution.

B. BETA GAMMA HAND & FOOT MONITOR :

Beta Gamma Hand & Foot Monitor manufactured & supplied by Nucleonix Systems has unique design features. This unit is installed in a ***medical cyclotron facility*** at the ***entrance / exit to Hot lab***. At the end of the day all the personnel working in the centre have to pass through this system to ensure that they are clean (Hands, foot & clothing) & not carrying any contamination. It is a widely accepted product.

C. AUTO TLD BADGE READER TL1010 :

Cancer Hospitals having large no. of personnel requiring personnel monitoring services for radiation dose measurments can opt for this system. Institutions wanting to have thier own equipment to record personnel doses by having AERB accreditation can go in for this system.



DIGITAL POCKET DOSIMETER- I (DIGIDOSE)
TYPE : PD 714

Technical Data

FEATURES :
- ❑ **High sensitivity Si-diode based design**
- ❑ Serves as an excellent pocket dosimeter.
- ❑ Compact, elegant light weight design.
- ❑ Measures both **cummulative dose** in the range of 1 μSv to 999999 μSv and **doserate** in the range of 100 μSv/h to 99.9 mSv/h.
- ❑ Battery life of more than 300 hrs.
- ❑ IR non-contact serial communication port for PC connectivity.
- ❑ Tolerant to mobile phone interference & also meets EMC requirements of ANSI N42.32 – 2003.

Digital Pocket Dosimeter Type **PD714** uses a high sensitive Si- diode as the radiation detector. This is designed to fit into pocket & has a spring loaded clip.
This serves as personel radiation Dosimeter to cater to the needs of radiation workers in Nuclear installations, Reprocessing plants, Radiochemical plants etc. It also finds use in medical, industrial, other applications where radioactive isotopes are used for a variety of applications.
It is also recommended as a personal dosimeter in Radiotherapy departments, nuclear medicine centres, cyctron & PET-CT centres.
It measures integrated radiation dose in the range of 1μSv to 99.99mSv and doserate in the range of 0.1mSv/h to 99.9 mSv/h.
The user interface to the instrument is through the LCD display and a single push button switch.
Its design is based on nano watt technology resulting in a battery life of better than 300 Hrs of continuous use.

Additional options :
i. Docking station for PD714
ii. Dose records data management software DS715.

SPECIFICATIONS

Radiation detected :
Gamma / X-ray

Detector : Si diode

Display :
4 digit 7 segment LCD display

Energy dependence :
+/– 25% in the range of 60 keV to 1.33 MeV

Range changeover: Automatic

Dose : 1 μSv to 9999 mSv

Dose rate : 1 to 9999 mSv/hr in low range
5.0 to 9999 mSv/hr in high range

Over range : 100% over range compliant.

PC connectivity : Optical port for communication with PC for configuration, calibration & data transfer.

Batteries:
3V Li-coin cell Type CR2354 size - 23.4mm x 5.4 battery to provide a life of approximately 300 Hrs.

Battery status :
Low battery indication on LCD

Electronics : PIC microcontroller based design.

Control :
i. A single push button for
a) Powering the unit ON
b) Viewing dose / doserate
ii. IR interface with PC
a. Setting / Reading ID of dosimeter in stored in memory
b. Setting / Reading issued / not issued status stored in memory.
c. Reading current dose reading
d. Resetting dose reading
e. Powering OFF the dosimeter

EMI/EMC compliance : Shall not be affected by RF over frequency of 20 MHz to 1000 MHz at an intensity of 10V/m as per ANSI N42.32 - 2003. Tolerant to mobile phone interference.

Dimensions :
30(W) x 125(L) x 14(D) mm, excluding clip

Weight : Approximately 60 gm.

IR DOCKING STATION (DS715) & DOSE RECORDS DATA MANAGEMENT SOFTWARE (DRMS)

Technical Data

FEATURES :

Hardware :

- ❑ Communication with dosimeters over IR port
- ❑ Connects to PC through USB port

Software :

- ❑ Automatic cumulative dose & ID readout or resetting of dose, into data base depending upon issued status
- ❑ Power OFF controlled through IR port.
- ❑ Data storage automatically after each readout.
- ❑ Dose records data base gives weekly, monthly, & yearly cumulative dose of individuals.

DS715 under the control of the PC communication software, primarily facilitates automatic readout of **Cumulative Dose** along with the **Unique ID** apart from **configuration/calibration** of the dosimeter. This Docking station DS715 is designed to for dosimeter PD714 which communicates with the Dosimeter through IR port and on the PC side it gets connected through the USB port. Docking station derives power through the USB port.

Dose records data management software (DRMS) is designed to read **stored total dose** from the dosimeter automatically once the dosimeter is placed in the docking station. It also facilitates assigning Unique ID for individual dosimeters, Calibration of the dosimeters for Cumulative Dose. The Application software routes data to Dosimeter through USB cable to/from docking station which in turn routes the data through IR port to the Dosimeter. Once the data is retrieved into PC, it gets recorded in a MS Access database. Users can retrieve and analyze data - ID-wise, Day-wise, Month-wise, Week-wise. Instrument power OFF is controlled through IR port by the software.

DIGITAL POCKET DOSIMETER
TYPE : PD 716

Technical Data

Digital Pocket Dosimeter Type **PD716** uses a high sensitivity Si-diode as the radiation detector. This serves as personnel radiation monitor with alarm to cater to the needs of radiation workers in Nuclear installations, Reprocessing plants, Radiochemical plants, etc. It also finds use in medical, industrial, other applications where radioactive isotopes are used for a variety of applications.
It measures integrated radiation dose in the range of 1μSv to 99.99mSv and doserate in the range of 0.1mSv/h to 99.9 mSv/h. It is also provided with preset alarm feature for generation of audio alarms in the event of high dose / doserate. The user interface to the instrument is through the LCD display and a single push button switch. The dosimeter is provided with an optical port for data communication with PC for the purpose of setting preset alarm levels and for calibration of the dosimeter.
Its design is based on nano watt technology resulting in a battery life of better than 500 Hrs of continuous use.

Additional options :
i. Docking station for PD716
ii. Dose records data management software DS717.

FEATURES :
- Silicon diode is used as the radiation detector.
- Micro-controller based design with custom LCD display.
- Serves as an excellent pocket dosimeter (worn on waist belt)
- Measures **cummulative dose** in the range of 1 μSv to 999999 μSv and **doserate** in the range of 100 μSv/h to 99.9 mSv/h.
- Battery life of more than 500 hrs. (Easily available AA cells)
- Preset alarm facility for cumulative dose and dose rate.
- IR non- contact serial communication port for PC connectively

SPECIFICATIONS

Radiation detected :
Gamma / X-ray

Detector : Si diode

Display : 4 digit 7 segment LCD display

Energy dependence :
+/– 25% in the range of 60 Kev to 1.33 MeV

Range : Automatic

Dose : 1 μSv to 9999 mSv

Dose rate : 1 to 9999 μSv/hr in low range 5.0 to 9999 mSv/hr in high range

Over range : 100% over range compliant

Alarm Settings :
a)Dose : 0 to 9999 μSv
b)Doserate : 0.1 to 99.9 mSv/h

Audio Alarm : 1 Hz alternating short beeps for dose rate and long beeps for dose alarm.

PC connectivity :
Optical port for communication with PC for configuration/calibration

Batteries:
2 × 1.5 V AA size alkaline /any batteries to provide a life of approximately 500 Hrs.

Battery status : Low battery indication on LCD

Control :
A single push button for
a)Powering the unit ON/OFF

b)Viewing dose / doserate
c)Muting doserate/dose alarm

EMI /EMC compliance : Shall not be affected by RF over frequency of 20MHz to 1000MHz at an intensity of 10V/m as per ANSI N42.32 - 2003

Dimension : 67W x 28H x 92L

Weight : 150gms. approximately

* Optional switch ON/OFF from PC
Note: Manufactured by NUCLEONIX SYSTEMS based on, Si-diode sensor Technology from Bhabha Atomic Research Center Mumbai.

IR DOCKING STATION DS717
DOSE RECORDS DATA MANAGEMENT SOFTWARE (DRMS)

Technical Data

IR Docking Station DS717 under the control of the PC communication software, primarily facilitates automatic readout of Cumulative **Dose** along with the **Unique ID** apart from **configuration/calibration** of the dosimeter. The Docking station communicates with the Dosimeter through IR port at a baud-rate of 1200. On the PC side it gets connected through the USB port. This Docking station DS717 is designed for docking PD716, derives power through the USB port.

Dose records data management software (DRMS) is designed to read **total dose** from the dosimeter automatically once the dosimeter is placed on the docking station. It also facilitates Configuration of Alarm Settings for Cumulative Dose and Dose-rate, assigning Unique ID for individual dosimeters, Calibration of the dosimeters for Cumulative Dose. The Application software routes data to Dosimeter through virtual comm. port to Docking station which in turn routes the data through IR port to the Dosimeter. Once the data is retrieved into PC, it gets recorded in a database. Users can retrieve and analyze data - ID-wise, Day-wise, Month-wise, Week-wise.

FEATURES

Hardware :

- ❑ Communication with dosimeters over IR port
- ❑ Connects to PC through USB port

Software / Firmware :

- ❑ Automatic cumulative dose & ID readout, into data base
- ❑ Facilitates configuration of alarm settings and dose calibration
- ❑ Data storage automatically after each readout
- ❑ Dose records data base gives weekly, monthly, & yearly cut dose of individuals.

Pocket dosimeter, worn on waist belt

IR docking station DS717

BETA-GAMMA HAND, FOOT & CLOTHING MONITOR
TYPE : BM731

Technical Data

FEATURES :

- ❑ Developed using state of art ARM7 based SBC working on embedded Linux platform and FPGA technologies.
- ❑ Provided with a 7 ½" colour TFT display for graphical & multi-lingual user interface during measurement mode. Voice & visual languages supported - English, Hindi, Tamil & Marathi.
- ❑ Uses LND719 for Hand, Foot & Clothing detector assemblies.
- ❑ Uses I/O interface is through a detachable keypad & colour TFT display
- ❑ Built-in RS485 & Ethernet interface using MODBUS protocols allow centralized monitoring and fault diagnostics.
- ❑ Monitor design ensures continuous maintenance free operation in harsh atmospheric conditions in Radiochemical plants.
- ❑ Designed in accordance to IEC61098 performance specification for personnel monitors.
- ❑ Built-in fault diagnostics for fault location or bypassing.

Beta-Gamma Hand, Foot & Clothing Monitor BM731 manufactured by NUCLEONIX SYSTEMS primarily serve as a personnel monitoring system for checking the contamination of hands, foot & clothing of radiation worker / technicians working in Nuclear Power Plants, reactors, Radiochemical plants and other similar installations.

This instrument has been developed using state of art ARM7 based SBC working on embedded Linux platform. GUI & multi-lingual user interface & corresponding voice messages are facilitated by a colour TFT monitor & a stereo sound device.

Guidance to the user during monitoring is in the form of colour graphic monitor for left / right hand / foot & status indications during monitoring & at the end of monitoring are a unique feature for Nucleonix systems make.

Advanced fault diagnostic features facilitate the user to diagnose the problem easily. Also provision for faulty channel bypassing feature has been provided. RS485 & Ethernet communication interfaces using MODBUS protocols facilitate remote monitoring, configuration & fault diagnostics.

Each Hand & Foot detector assembly shown in figure is modular in construction with two detectors plugged onto a single detector socket box, facilitating easy maintenance incase of problems.

SPECIFICATIONS

The Beta Gamma Hand, Foot and clothing monitor comprises of a set of detectors and an electronic unit.

DETECTORS:

a) Hand probes:

- Number of monitoring channels: 4 (Right hand upper & lower, Left hand upper & lower).
- Detector type : Halogen quenched G.M. detectors Type LND 719 or equivalent.
- Detector Wall Material : 40 - 60 mg/cm2
- Detection Efficiency : 3-4% for Beta Gamma over complete detector area for each face of the hand with Sr90 phantom source.
- Probe Construction : Each channel uses 2 G.M. detectors. The detectors are provided with Lead shielding of 25 mm thickness to keep the background counts below 100 counts in 20 secs. counting time. They are fabricated and fitted in the instrument so that they can be detached easily for maintenance.
- Sensitive Area. : 300 sq. cm.
- Protection Grill : The whole detector assembly is protected by a suitable thin metallic grill.
- Detector dimensions and performance conforms to IEC 61098 specifications.

b) Foot probes:

- Number of monitoring channels: 2 (Right foot and Left foot).
- Detector type : Halogen quenched G.M. detectors Type LND 719 or equivalent.. / Pancake detector.
- Detector Wall Material : 40 - 60 mg/cm2
- Detection Efficiency : 2-3% for Beta Gamma over complete detector area with Sr90 phantom source
- Probe Construction : Each channel uses 2 G.M. detectors. The detectors are provided with necessary Lead shielding of 25mm thickness to keep the background counts below 100 counts in 20 secs. Counting time. They are fabricated and fitted in the instrument so that they can be detached easily for maintenance.
- Sensitive Area. : 300 sq. cm.
- Protection Grill : The whole detector assembly is protected by a suitable thin metallic grill and foot support.
- Detector dimensions and performance conforms to IEC 61098 specifications.

c) Clothing probe:

- Number of monitoring channels: one
- Detector type : Halogen quenched G.M. detectors Type LND 719 or equivalent. / Pancake detector
- Detector Wall Material : 40 - 60 mg/cm2
- Detector Plateau : Shall have minimum plateau length of 200 volts and shall be insensitive to ordinary light.
- Detection Efficiency : Greater than 2 - 2.5% for Beta gamma over complete detector area.
- Probe Construction : Hand-held type; Side window probe in a protective housing with a rotatable shutter for cutting off beta particles. It shall be placed on a holder with micro-switch assembly on the side of the monitor. On lifting the detector, the monitoring shall be started.
- Detector dimensions and performance shall conform to IEC 1098 specifications.

ELECTRONIC UNIT :

The electronic unit consisting of the following

a. Signal processing and display unit.
b. Mother board
c. Switched mode LV supplies unit
d. 13 channel pre-amplifier unit
e. High voltage power supplies unit

Signal processing and display unit : The signal processing & display unit comprising of an ARM7 based SBC & 7 ½" LCD is the data acquisition & control device. It carries out the following functions of

- User interface during configuration & measurement through the 7 ½" TFT display, 4x4 matrix keypad and optical sensors.
- Counting of pulses from 13 individual detectors.
- Storage of last 100 acquired data and last 100 contamination data.
- Configuration of various parameters like PM time, BG time, BG dwell time, Low BG set point, High BG set point, Alarm set point, Baud rate, Device ID, IP address, Voice & visual guidance languages, fault diagnostic configuration, detector efficiency, detector status etc.
- Interfacing with status & alarm indicating bar LEDs during measurement cycle.
- Generation of voice guidance messages through stereo O/P sound device during measurement cycle.
- Initiates / terminates measurement cycle by sensing optical sensors status.
- Communicates to remote PC through RS485 / Ethernet ports using MODBUS protocol.

Mother board : Signal from the pre-amplifier unit optical sensors, RS485 port control & reference signals for HV module are routed to the signal processing unit through this board. The LV supplies to all the sub-systems are routed through this board.

Switch mode power supplies unit : An AC-DC converter generates the necessary PC voltages of +12, +24 & +5V necessary to the power the electronic sub-systems. It is also provided with a line filter & other EMC suppression components.

13 channel pre-amplifier unit : This unit comprises of 13 individual pre-amplifier modules used for connecting the -ve tail pulses to TTL coming from each of the GM detectors. HV bias to the GM tubes is fed through the pre-amplifier unit.

- **Counting Range :**
  0 to 9999 counts
  0 to 9999 CPS
  0 to 9999 Bq
  0 to 99999 CPM
  On overflow the display indicates 'OVR'

- **Timing range :**
  Pre-settable from 1 to 99 seconds in 1 sec steps for COUNTS, Bq, CPS or CPM modes for Hand and Foot monitoring. Time constant for checking the Clothing monitoring is 5 seconds with display being refreshed every second

HUMAN MACHINE INTERFACE:

Indications & controls:

Mains switch : The mains switch is provided inside the cabinet of the monitor.

Mains indication : Red LED to indicate mains power ON is provided on the display panel.

Optical sensor : The monitor is provided with optical sensors inside the detector cavities for initializing the counting.

Test switch : This is a momentary push button switch provided on the side panel used for doing test acquisition

Visual alarm : Each channel visual mimic indication on LED indicators and additionally color mimics for each channel are provided on the colour LCD display.

Audio Alarm : Loud audio tone.

Audio Instructions : Audio instructions are generated for clear, contaminated, instrument fault, monitoring in progress and incomplete operation.
Multi-lingual messages are played back in either Hindi / Tamil / Marathi based on the selection.

Operational Guidance : Operational guidance messages are displayed Before monitoring, On Clear, On Contamination and On Incomplete operations are generated in either Hindi / Tamil / Marathi apart from the primary language English.

Incomplete operation : Yellow LED indicator along with Multi-lingual textual indication accompanied by audio alert are generated when counting is interrupted.

Clear Indication : Green LED indicator and LCD mimic indicator will be ON when all the channels are clear.

Counting in progress Indication : Busy LED indicator will be ON and Time left is displayed when counting is in progress.

Visual display : 7.5" colour LCD display.

Given below is a partial list of the functions being carried out by the visual display.

- Display normal status messages.
- Visual display of monitoring in progress (including count down of time in seconds)
- Display of individual channel readings
- Alarm annunciation
- Background checking and display
- Instructions for use.
- Self explanatory, language independent symbols / user instructions.

Computer interface : (RS485 optional)
The monitor has a RS485 serial & Ethernet 10/100 Mbps port for interfacing with a remote IBM PC-compatible computer. The features supported by Ethernet port are given below.

- The PC and the monitor operate in a host-slave configuration and the software protocol will be MODBUS/RTU or MODBUS / TCP
- The firmware of the monitor will be able to send the instrument data like Instrument ID, Instrument type, Maximum counting range, Timer range, alarm settings, alarm status, current reading etc. to the Host PC on demand.
- The firmware will be able to receive commands from Host PC and carry out the setting of different parameters like Instrument ID, Instrument type, Maximum counting range, Timer range, alarm settings, instrument address etc.
- The PC as the host will give commands and send queries. The monitor will carry out various functions in response to the queries.

Power supplies : The monitor has a High voltage power supply unit for the detectors and a low voltage power supply unit which supplies the DC power supplies required for the Electronic unit. It has a very good line voltage and load regulation for all the supplies. It is fitted with Mains line filters to avoid line interferences. The High voltage output is adjustable by handheld configurator or host PC and EHT is displayed on the display on demand. The EHT is adjustable from 300 V to 1500 V DC.

Instrument fault indication : Fault diagnostics are carried out periodically and any failures are reported on the display like LV, HV and detector failures.
Fault indications are cleared automatically if normal status is resumed.

Housing:

- Most of the modules of the Electronic unit and detectors are integrated into a column shaped cabinet with castor wheels.
- The hand probes are fitted so that both the hands can be inserted and the optical sensors inside the cavities are activated when hands are placed to start monitoring.
- The modules are plug in type with all the controls and display on the front panel.
- The cabinet is rat-proof, rugged & elegant.

Self diagnostics : The monitor has built-in self diagnostics. On being powered it performs tests to ensure that all components and sub systems are functioning properly. It checks for the Power supply, High Voltage Supply, Detector, Counting and measuring circuits, Alarm Systems, Display Systems and communication port.

The firmware is designed for high reliability and availability.

Test points are provided for checking the EHT voltage and for connecting external input pulse signals.

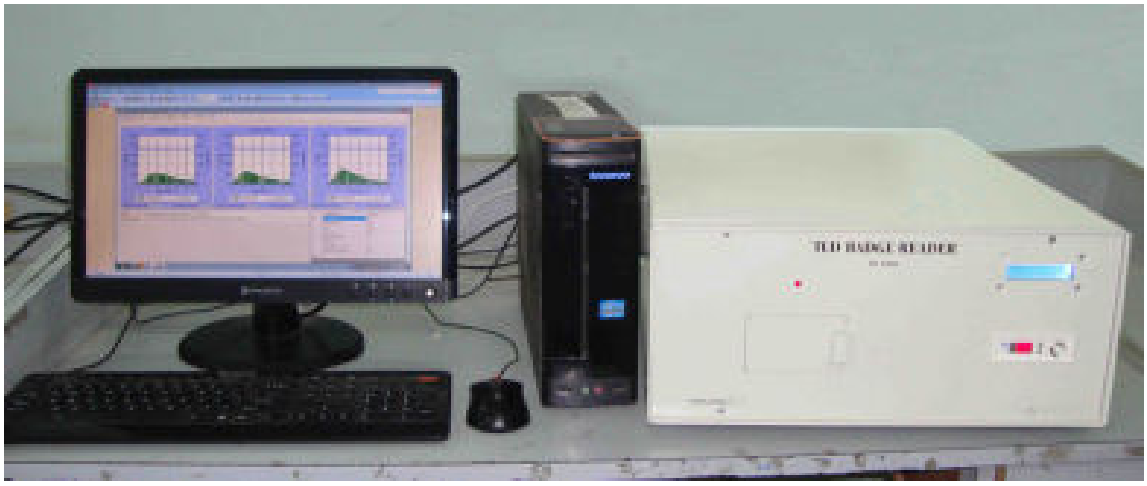
Input Power : 230VAC +/-10%, 50Hz, single phase supply. Power ON/OFF indication is provided with an indicator LED. Line filter and spike suppressor shall be provided.

Environment : The instrument will be able to withstand temperature upto 50°C and relative humidity upto 90% in radiation areas.

Environmental EMI / RFI performance compliance : This instrument is designed to comply to IEC 61098 for its radiation performance environmental & EMI / RFI compliance. For EMI / RFI compliance test specifications specified by IEC61000 standards are applicable.

AUTOMATIC TLD BADGE READER
TYPE : TL1010A

Technical Data



Key Hardware Features :

- All DC motors are replaced by low power & low noise stepper motors for precise motion.
- Proven Nichrome Heater assembly, is used in the design.
- Ni63 based **light source card** is used for PMT gain stability check as & when required.
- **Digital Flow rate** measurement instead of rotameter based design to ensure flow rate is within limits during entire readout cycle. This prevents readout when gas flow is beyond limits.
- Improved heat dissipation to prevent temperature rise within the PMT assembly resulting in better stability of readings.
- SMPS based power supplies for operating over wide voltage ranges.
- Mother board based design for easy maintenance of electronic sub-assemblies.
- Uses compact imported HV module for high stability and low ripple & drift.
- Automatic magazine home recognition & positioning.
- Reads 2 disc & 3 disc TLD cards with 2 row & 3 row punched ID code as per Nucleonix design.

Auto TLD Badge Reader TL1010A is a personal monitoring system, designed to read the TLD card (TL dosimeters) worn by radiation workers.

This Badge Reader system is designed using state of art electronics, improvised electro-mechanical system, embedded code and software to load and read the TLD cards for TL glow curve / dose. System facilitates entry of ID number for the person and his dose record and glow curve can be stored in the system. TL dosimeter is heated by hot gas (N_2) jet to 280° C using a Nichrome heater assembly & TL output is recorded using PMT where integral of the current output is proportional to the dose.
It is a Thermoluminescent dosimeter based personnel monitoring system. Thermoluminescent dosimeters make use of the property of certain materials which absorb energy when exposed to X, Gamma or Beta radiation. On heating, the absorbed energy is released in the form of visible light. A plot of light intensity emitted against temperature is known as a glow curve. For a given heating rate, the temperature at which the maximum light emission occurs, is called the glow-peak temperature and it is characteristic, of the individual TL material (also called phosphor).

The quantity of the visible light emitted (TL output) is found to be proportional to the energy absorbed by the TL material.
The TLD personnel monitoring system essentially consists of two major parts: TLD badge and the TLD badge reader.
The TLD Badge comprises of a plastic cassette containing Two or Three Teflon TLD discs (13.3mm and 0.8mm thick) that are mechanically push fitted on to circular holes (12.0mm) punched in an aluminium card.
The Badge has 2 or 3 row punched ID code as per user requirement.

The TLD Badge Reader is designed to measure X, Gamma and Beta radiation dose. The metal filter combination (1mm Al + 0.9mm Cu) is provided to reduce the photon energy dependence of the TL discs. The TL badge reader is calibrated such that the TL output of the disc under the metallic filter reads directly the gamma radiation dose.

SPECIFICATIONS

A. HARDWARE SPECIFICATIONS :

Dosimeter :
Three-element BARC $CaSO_4$ (Dy) PTFE disc dosimeter badge with personnel ID punched on the TLD card.

Light Measurement System :
Photo-multiplier tube (R6095 or its equivalent) bialkali Light measuring system (LMS)

Dark current :
Dark current is 1 μSv ($CaSO_4$) equivalent with software-based sampling & subtraction.

Heater Element :
Nichrome wire heater assembly.

Heating Method :
Once temperature reads 280°C TL disc of the TLD cards are positioned in front of the heater for readout and acquisition cycle goes ON for 30 sec for each disc.

Nitrogen flow rate measurement:
Digital flow rate meter

Heating Cycle :
The temperature is raised to 280° C in 8-10 sec and clamped at 280°C

Dose Range :
Reader is capable of reading badges from 50 μSv to 2.0Sv automatically and the dose response is linear over the entire range.
50μSv – 1.0Sv (Gamma) and
100μSv – 10Sv (Beta)

Dose Threshold : <50μSv

Readout time : 100 sec. per badge

Residual TL : 8 to 12% of initial TL in the linear dose range specified.

Light source : A **Ni63 based light source with punched ID card** is provided for PMT check & gain adjust.

Flow Rate Measurement : A **digital flow measurement system** is provided for flow rate measurement & failure check.

Facilities Available: Entry of personnel details corresponding to each badges for editing of calibration factor etc. Storage of dose and glow curve data of badges in database. **Stepper motor** based drive assembly is provided for magazine & TLD card transport in a magazine. Digital linear actuators are used for TLD card raise & shutter control.

Software : Win 7 compatible software developed on .net platform for storage of readings in a database and display of glow curves, computations of dose & generation of dose reports.

Temperature Monitoring :
Two Chromel Alumel thermocouples in hot gas stream, one called 'Heater Thermocouple' inside heater & the second called 'Air Thermocouple', in hot gas stream.

Range Selection : Auto-changeover

Calibration :
Coarse adjustment by varying the EHT through a potentiometer in the EHT circuit.

Safeguards :
Heater/Gas flow failure: The heater and gas flow are checked for failure in every dosimeter readout cycle. In the event of failure of heater or gas flow the readout is terminated and a message indicating heater / gas flow failure is flashed on the PC monitor. Mechanical Failure: Any mechanical failure during readout cycle is sensed by the programme and the cycle is terminated with an option for the user to restart the cycle. EHT & input circuit (I-F converter) are also sensed and reading cycle is terminated in case of failure.

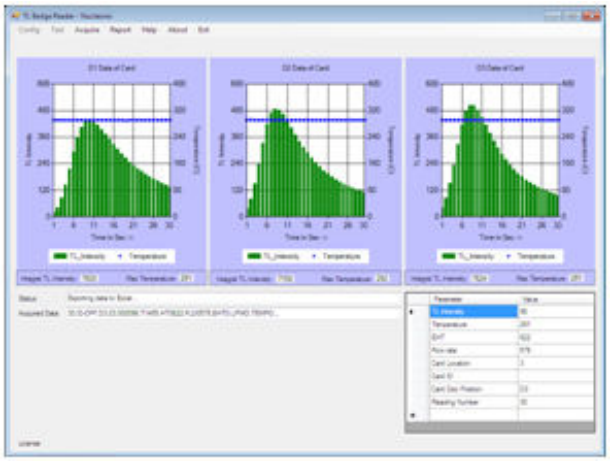
Nominal Power Supply :
Power supply : 230V, 50Hz : +/-10%
Power requirements: 500 VA (max including PC).

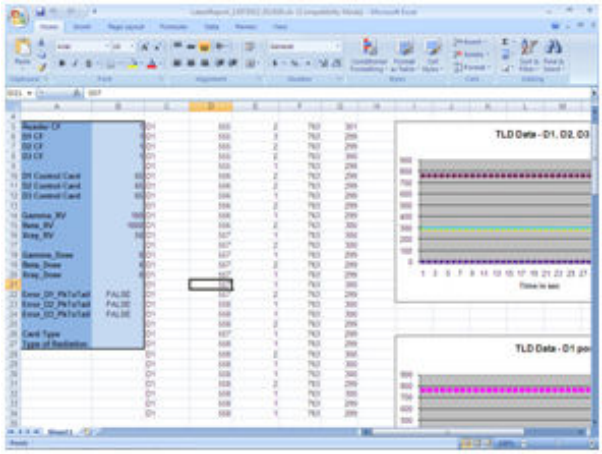
PC Requirements:
Suitable latest PC configuration with win 7 Operating system or as requested.

Applications:
Personnel Monitoring of radiation workers in Nuclear power stations, Isotope laboratories, Industrial radiography installations, diagnostic & therapeutic radiology centres, etc.

B. SOFTWARE FOR TL BADGE READER

The software for TL Badge reader serves as comprehensive 'TL Dose records management software'. It is user-friendly, reliable and feature rich. It has powerful fault diagnostics reporting capabilities.





Key features of Software:

- Provides Commands for complete control & fault diagnostics of the Reader that includes checking of Light Source, Dark Current, Heater, Gas flow, EHT, Mechanical movements.
- Provides screen to enter Institution, Personnel and Card details prior to acquisition.
- Acquisition of up to 50 cards can be done in one go.
- During acquisition, parameters like EHT, Temperature, TLD number, Institution number, File name, Card position in magazine, card number, TL glow curve is displayed on screen.
- Acquisition can be paused & resumed without any loss of data.
- Fault checks are performed during acquisition and reported to user.
- Calibration factors for Reader and D1, D2, D3 positions can be set.
- Dose calculator is provided for calculation of Dose by manually entering Integral TL values for D1, D2, D3 positions.
- Glow curve data is stored in Text file and can be optionally exported to Excel.
- Glow curve data can be viewed at a later data individually for each card & printed.
- Dose values for each card, Personnel numbers are written to a batch file.
- Dose information can be optionally written to Nucleonix Dose Records management database and User wise Cumulative Dose reports can be generated.

Suggested spares:

- Solenoid valve
- Heater assembly
- Heater coil
- Opto interrupter boards
- Digital rotameter
- EHT module (0-1200V @ 0.5A)

Additional Accessories / Items Required for personnel / environmental TLD Lab

(i) Two / Three element $CaSO_4$ (Dy) PTFE disc dosimeter badges with 2 or 3 row personnel ID.
(ii) Magazine to hold 50 TLD cards
(iii) Annealing oven
(iv) Nitrogen cylinder / Generator with regulator
(v) Radioactive source exposure device for TLD cards calibration
(vi) Light Source Card

** Note : Manufactured by NUCLEONIX SYSTEMS based on original Technology received from Bhabha Atomic Research Center, Mumbai, by incorporating improvements in design to achieve high reliability.*

c. ACCESSORIES

(i) HOT AIR ANNEALING OVEN

In Hot Air Annealing oven there is one path of circulating Hot Air in between the inner chamber and insulation. Forced Air Moved by the motorised blower is called Perfect System. It result minimum temperature variation at any point in working space. Temperature controlled by PID type Digital controller cum indicator with safety alarm from room temperature to 350/400° C with a sensitivity of +/- 1° C cr better in Bare Oven. Working chamber is made of stainless steel and outside made of mild steel painted with good stoving enemel with adjustable trays. To work on 220 /230 volts A.C single phase supply.

Working Chamber size :14" x 14" x 14" (Approx) ; Litres :43

No.of trays : Two

Heaters: 80/200 Nichrome elements

Working Temperature : From ambient to 350° C / 400° C

Temperature Accuracy: +/- 1 degree, in bare oven

Temperature Indication & Control: Temperature controlled by PID type digital controller cum indicator with safety alarm

Digital timer : Digital timer of (0-99) Hrs can be set

Air circulation System : For maximum uniformity of temperature inside the working chamber, air circulating system is provided by means of a meter driven fan.
Heaters : Heaters are made out of best quality Nichrome Wire insulated with refractory runners and enclosed in stainless sheet and fitted to the sides of the Oven.

Construction of Oven Body:
Interior : Polised stainless steel 304/ Anodized Aluminum / SS.316 (GMP Model)
Exterior : Heavy gauge Mild steel / SS304 (GMP model)
Chamber : Double Walled
Ventilation :Air Ventilators are provided near the top of the sides for removing hot gases and fumes
Insulation:75mm thick Mineralwool
Shelves : sturedy Elegant – fabricated precisely to give minimum resistances to air circulation.

Finish : Finished with attractive and durable powder coated in pleasant shade

Door : An insulated hinged side swinging type double walled door with asbestos gasket, ball catch lock and handle provided for easy and effortless closing & opening of door.

Insulation: High grade ceramic fibre blanket insulation is provided on all the six sides of the Oven
Power Rating:2.5 K.W.

Input Supply : Single phase AC, 230 Volts

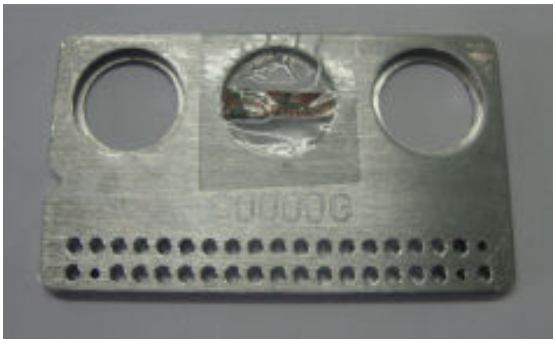
(ii) TLD CARD

Three CaSO4: Dy Teflon TLD discs are mechanically clipped on an Aluminium plate with a punched code ID. An asymmetric "V" cut is provided in the card to ensure its loading in the plastic cassette as well in heater drawer / magazine of TLD reader in only one orientation. Aluminium card should be uniformly Nikel plated or buffed, having plating thickness of about 10 micron. A 2 row punched code is provided on the TLD Card for automatic personnel ID readout by the instrument.

Characteristics of $CaSO_4$: Dy Teflon TLD disc

Ratio of CaSO4 : Dy and Teflon	:	1: 3
Effective Atomic Number (Z)	:	15.1
Density of the TLD Disc	:	2.52 g/cm3
Softening Point of Teflon	:	330° C
Main Glow Peak Temperature	:	230° C
Sensitivity of TLD Disc	:	About 30-40 times more than LiF TLD-100
Fading	:	2-3% in six months
Climactic Effect	:	Negligible
Effect of Sunlight	:	Negligible when covered by paper wrapper & polythene pouch and loaded in the badge
Useful Linear Dose Range	:	0.10 mSV to 20 SV (linearity within + 10%)
Reusability	:	20 cycles
Beta Response	:	60% of Co-60 gammas for Nat.U (effective energy 0.8Mev)
Thermal Neutron Response	:	Co-60 gamma ray equivalent to 2.4 mGy per 1010 n/cm2
Fast Neutron Response	:	Negligible

LIGHT SOURCE CARD: Ni-63 wrapped inside plastic scintillator, mounted in a dummy TLD card is used as the light source. This can be placed in a magazine to read PMT stability counts, whenever required over the day. This eliminates disadvantages encountered in the previous design, such as Ni-63 getting over headed along with plastic scintillator there by causing damage to Ni-63 source.



(iii) TLD Cassette

- Three well-defined regions in the plastic cassette / holder corresponding to three TLD discs of the TLD card.

  i. Disc D1- sandwiched between a pair of filter combination of 1.0mm thick Cu (Copper filter nearer to the disc).
  ii. Disc D2- sandwitched between a pair of 1.6mm thick (180mg/cm2) plastic filters and
  iii. Disc D3- under a circular open window.

- The asymmetric "V" cut of the card permits its loading in the plastic cassette in only one orientation and ensures proper positioning of three disc.

- For identification purposes, photograph of the user could also be permanently fixed on the central transparent region of the badge.

- There are two types of TLD badges/ cassettes in use namely,

  1. Chest Badge for whole body monitoring and
  2. Wrist Badge for extremity dosimetry

  Though the dosimeter and design of both TLD badges are same, they have different attachment (clip/ strap) for wearing purpose depending on their use.

TLD CASSETTE DIMENSIONS

In this design of the TLD cassette, dimension of some of the filters was altered and crocodile clip was replaced by a smaller size clip. The cassette was made of ABS plastic (white) and filters were embedded into the plastic body.

MISCELLANEOUS PRODUCTS

1. Well type Nal Scintillation Detector based Gamma Ray Spectroscopy System with 1K/4k/8K MCA

This system is an ideal choice for medical cyclotron facility to test for isotope purity & identification of energy of the medical isotopes such as FDG / F-18 or Tc-99, I-131 etc., produced, for use in PET-CT centres.

2. PC Controlled Thermoluminescence Reader
Type : TL 1009I

TLD Reader is an essential useful tool in Radiation oncology departments. Both in research studies as well as patient dosimetry.

Other applications include, Therapy machine calibration checks & inter-comparison studies with other centres, treatment planning accuracy verification using phantoms, patient specific dosimetry, studies in Brachytherapy physics, in X-ray diagnostics to determine absorbed doses to patients & in research etc.

NaI SCINTILLATION DETECTOR (WELL TYPE) BASED GAMMA RAY SPECTROSCOPY SYSTEM WITH 8K MCA

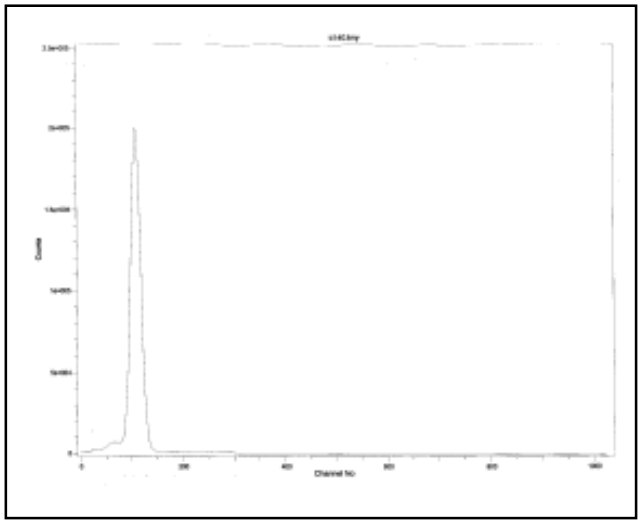
Technical Data

FEATURES :

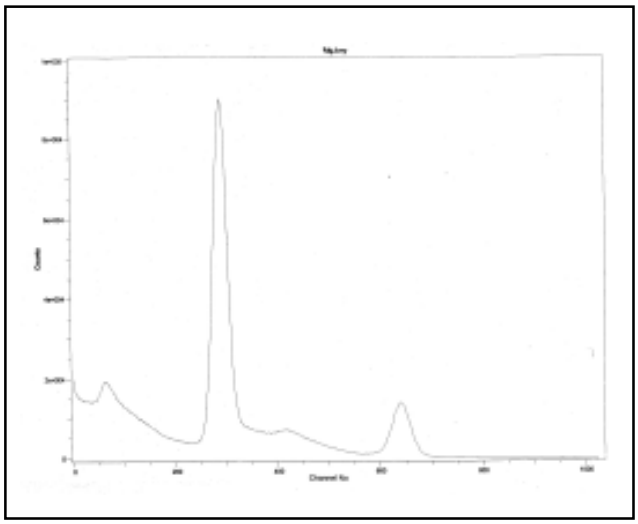
- This system is an ideal choice for medical cyclotron facility to test isotope purity & energy identification of the medical isotopes produced, for use in PET-CT centres.
- 2"x2" NaI well detector facilitates loading of the samples in a vial or test tube for spectrum acquisition.
- FDG / F-18 or Tc-99, I-131 etc., or other isotopes produced can be checked for isotope purity & energy identification.
- System has 1K/4K/8K MCA with USB interface.
- Software has energy, efficiency activity calculation menus.
- Detector resolution is better than 8.5% for Cs-137.

NaI Scintillation detector (well type) based gamma ray spectroscopy system is a versatile essential system required in the Q.C Lab of medical cyclotron facility. This system is used to test isotope purity & energy of the Radio-nuclides such as FDG / F-18 or Tc-99, I-131etc., produced in a medical cyclotron. These isotopes are sent to PET-CT centres & Nuclear medicine centres for applications & use on patients. Basically isotope produced is loaded into the vial & is placed into the well of the 2"x2" NaI scintillation detector to acquire PHA spectrum of the Radio-Nuclide which will indicate purity of the isotope & indicate the energy.

Essentially this system consists of the following constituent units (1) a 2"x2" well type NaI integral assembly detector with lead shielding arrangement (2) High voltage unit (3) Shaping amplifier, (4) Instrumentation bin with power supply, (5) 1K/4K/8K MCA (USB based) (6) Personel computer with data acquisition & processing software.



Technetium-99m, 140keV peak



FDG (F-18), 510keV peak

SPECIFICATION

MINIBIN AND POWER SUPPLY MB 403:
Mini bin : Accommodates SIX / EIGHT single bit modules or combination of multiple widths with Amphenol connectors. Minibin is primarily designed with the objective of conserving bench space and to achieve significant saving in cost of the Minibin based systems. Bussed wiring is provided to the power connectors to distribute +/- 12V and +/- 24V. A control panel with ON/OFF switch, low voltage test sockets is provided on the right extreme side of the bin.

Minibin Dimensions : 11.75"width X 11.00 depth (upto connectors) X 8.75" height.

Power supply : This is either two and half bit module or a compact box type enclosure fitted at the back of this bin, which generates highly regulated D.C voltages.

Input : (230V + 10%) a.c, 50Hz.

D.C Output : +12V @ 1A, -12V @ 1A, +24V @ 0.5A, -24V @ 0.5A 48 watts maximum.

Regulation : Better than +/- 0.1%

Noise & Ripple : Less than 3 mv

Stability : +/- 0.5% after a 24 hr warmup at constant line, load & ambient temp.

HIGH VOLTAGE UNIT (HV 501) :
a. Output voltage variable continuously from 0V to 1500 volts
b. Output current (max) 1mA
c. Load & Line regulations : Better than 0.005% of full scale
d. Indefinite over load & short circuit protections and self recovery
e. Output ripple less than 20mv.
f. Dimensions : Single / Two bit module

LINEAR AMPLIFIER (LA 520) :

a. Input Polarity	:	Positive or Negative
b. Total gain (Typical)	:	1000 (approx)
c. Output (Unipolar)	:	0 to 8V
d. Max. output (Unipolar)	:	12V
e. Dimensions	:	Two bit module

LEAD CASTLE : This Lead Shield is designed to shield 2"x2" NaI detector Scintillation Detectors of NUCLEONIX make. It is built-up of interlocking rings with bottom and top plates. The bottom ring is provided with a small opening so that the cables from the Scintillation Detector Pre-amplifier base could be taken out for connecting to the Gamma ray spectrometer counting system.
The inside of the lead shield is lined with Aluminium to minimise scattering.
Thickness 40mm, accommodate 2" scintillation detector including sample.

WELL TYPE SCINTILLATION DETECTOR (SD151W): This detector assembly consis of a vertical housing with built-in preamplifier in to which 2"x2" well type intergral assembly is plugged in.
This is designed to be table top mountable assembly. This load samples in test tubes for counting.

a. Crystal Sizes	:	2" x 2"
b. Well Size	:	0.656" dia x 1.546" deep
c. Resulation	:	Better than 8.5 %
d. Noise (RMS. referred to input)	:	Less tha 50μV
e. Operating Voltage	:	700 to 900V
f. Out put	:	Positive Tail Pulse
g. Output impedance	:	90 Ohms
h. Power Requirement (Typical)	:	-12V @ 12mA

MULTI-CHANNEL ANALYZER (8K MCA) WITH PROCESSING SOFTWARE : Multi-Channel Analyzer (MCA) is an important part of nuclear spectroscopy system. The major requirement of MCA is for nuclear pulse height analysis in energy spectroscopy. The USB-MCA presented here, incorporates state of art technologies like FPGA,USB bus interface and precision analog electronics to meet the stringent system requirements in nuclear pulse spectroscopy. The resolution supported by the USB-MCA ranges from 256 channels to 8K channels selectable via software, making it suitable for all spectroscopy applications from low resolution (e.g. NaI-PMT) to gigh resolution (e.g.HP-Ge) systems.

The USB bus interface of the MCA provides an excellent connectivity with most of the new PCs and lap-top computers. The PHAST application software provided with the USB-MCA, seamlessly integrates with the hardware, featuring a range of standard functions required for analysis and acquisition.

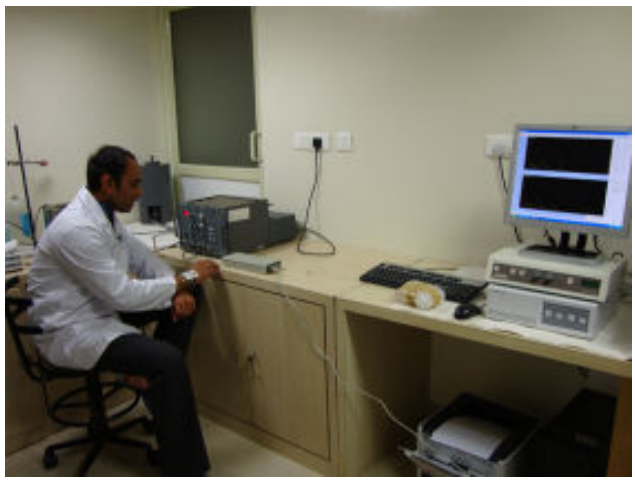
SPECIFICATIONS :

Hardware features:

- MCA resolution: 256, 512, 1K, 2K, 4K and 8K channels.
- Spectrum memory : 128K bytes single port SRAM.
- Max counts / channel: 31 bit (2 Giga counts).
- Pulse processing time : 7 μs including ADC conversion time of 5 μs.
- Pile up rejection: Active high TTL input from spectroscopy amplifier
- DNL: + 1%
- INL : + 0.05% F.S.
- MCA Input: Single channel, 0 to +10 volts
- Power requirement: 5V, ~500 mA through USB cable directly (No external power supply required)

Software features: Important software features include * spectrum display in two windows * marker selection (two) for ROI Detection & bracketing the peaks of interest, multiple ROI selection, delection of ROIs etc.,
File Handling: Involves storing, loading of complete spectrum.
Print: Print of Total graph, selective graph, peak report
Acquistion: With pause option
Erase: Erasing spectrum from memory
Spectrum Analysis: Find peak, Shape calibration, Energy calibration, Approx Calib, Efficiency Calibration, Activity Calculation, etc.,
Spectrum smothing: 3,5,7,9 &11 point smothing functions have been provided
ROI Option: Insert, Delect, Hide Etc.,
Scale: X-axis can be choosen as Channel number (or) Energy axis (in Kev) & Y - axis has range from 256 to 64M in binary steps with auto scaling option. Y-scale can be linear or log LLD, ULD & base line are soft selectable In built Isotope library for istope selection & matching.

PERSONAL COMPUTER SYSTEM WITH PRINTER : Any standard pentium IV computer configuration with printer is adequate to run MCA software.



NaI Scintillation Detector (well type) based gamma ray spectroscopy system with 8k MCA, installed in QC lab of a medical cyclotron facility. System is used to test isotope purity & energy of the Radio-nuclides such as FDG / F-18 or Tc-99, I-131etc., produced

PC CONTROLLED THERMOLUMINESCENCE READER TYPE : TL 1009I

Technical Data

FEATURES :

- Micro Controller based Integral system and works as a PC controlled TL Reader.
- Built-in USB port facilitates connection to PC
- **Heating rates** are 1°c/sec to 40°c/sec.
- Max. set temperature 500°c.
- **Heating profile :** Linear, plateau heating (One/Two/Three).
- **Software features** include glow curve, acquisition, display, filing, printing, processing over lapping Area under peak, subtraction etc.

Thermoluminescence Reader Type TL1009 designed and offered by NUCLEONIX SYSTEMS is a versatile controller based unit, facilitating the user to subject the TL sample under study to the desired heating profile, to record the digitized TL glow curve. This unit stores both integral value and digitized glow curve into EEPROM memory.
This unit records the data in 200 channels, temp, TL intensity & Run time values.
Entire electronics including PMT, HV bias, Temperature controller circuit, Heater transformer heater strip, sample drawer assembly, data acquisition electronics is all integrated into a single enclosure.
The user interface to the unit is through a powerful software GUI, coded in .net which runs on Windows platform. This system essentially works as a **PC controlled TLD reader** with command buttons and dropdown menus defined for various functions.
Built-in USB port in the unit facilitates the user to connect it to a PC for GUI and to achieve full functionality. PC is not include scope of the supply. This system is provided with an optional CCD spectrometer as an additional attachment, which enables one to record TL intensity Vs wavelength.

HARDWARE SPECIFICATIONS

PMT housing and TL sample heating assembly:
This unit has a low dark current photomultiplier Tube generally of Hamamatsu / ET make, is used. However, assembly facilitates one to go in for other photomultiplier Tubes also with appropriate modification in the PMT socket wiring.
The cylindrical shell containing the Photomultiplier is fitted on to a rectangular base drawer block containing a heater arrangement and thermocouple, heater rods, connected to a power transformer.

Heating Process:
Programmed heating can be done in two modes:
"PROG MODE" of Temp. controller through personal computer program.
"ISO MODE" (Internal mode) of Temperature Controller, by varying the ten turn dial.

Temperature Sensor:
Thermocouple Sensor (Cr-Al spot-welded to heater strip).

High voltage to PMT: A continuously adjustable HV (0-1500V) @1mA is generated by HV circuits. User can select desired HV from front panel. There is HV socket (test) for checking HV presence on rear panel.

Heating Rates: Heater strip can be programmed to heat the sample from 1° C/sec upto 40° C/sec and a max set temperature (allowed) is 500° C.

Arrangement for Optical Filters :
One Heat absorbing glass / filter (IR cutoff filter): This is essentially an IR cut-off filter which allows only visible light and cuts- off IR Radiation has been provided just below the PMT window. Additionally filters (Band pass) if required by the user may be positioned above the slot provided on the heater strip in the drawer assembly.

PMT: PMT used is, of 11 dynode 29mm, low dark current PMT of ET enterprises make.
Dark current at 20°C = 0.2nA
Max. cathode to anode voltage = 2000V

Heating Arrangement:
Resistive heating method.

Heating Element: (Heater Strip)
Kanthal strip (72% Fe, 23% Al and 2% Cr or Nichrome) is used as a heating element.

Kanthal Strip has a circular depression of 14mm to hold discs and powder samples. Additional flat heater strips can be provided on request.

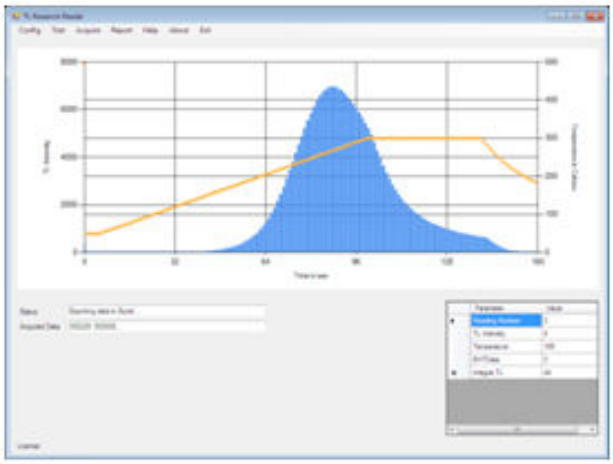
Auto-Ranging: Current output from the photomultiplier is taken to I-F converter, to give frequency output proportional to PMT current. This wide dynamic range is achieved for plotting TL intensity on Y-axis.

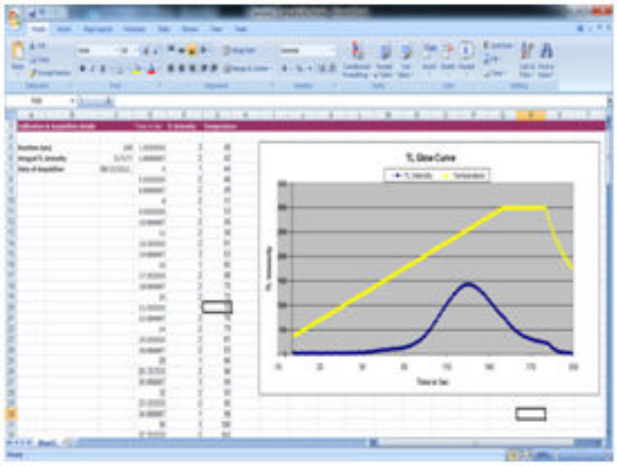
Temperature range: From room temperature upto 5000 C, in linear, plateau heating (One / Two / Three) modes of heating can be programmed.

Nitrogen Flushing Nozzle:
Nitrogen gas flushing (sent through a flexible rubber pipe), suppreses spurious luminescence from oxidation effects & combustion phenomena has been provided, on the rear panel side.

Dimensions of Integral unit:
25.5W X 26ht. X 48D in mm

SOFTWARE FOR TL RESEARCH READER
The software for TL Research reader is advanced, user-friendly, reliable and feature rich.





Key features of Software:

- Provides convenient temperature calibration.
- **Multi-plateau temperature profile** definition along with visualization.
- Multiple temperature profiles can be saved & retrieved as and when necessary.
- **Calibration factor** for Reader can be set.
- **Background subtraction.**
- Selection of Region of Interest (ROI) will automatically calculate Integral TL Intensity for the region.
- Glow curve data is acquired and stored in Text file as well as Excel along with Timestamp.
- Glow curve data can be viewed at a later date either in App or in Excel.
- **Overlapping** of up to 10 Glow curves is possible. Data can be exported to Excel and printed.

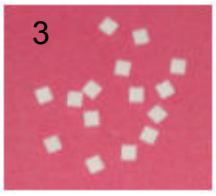
APPLICATIONS :
TL Phosphor Characterization, Medical Dosimetry, Personal Monitoring Research, Archeology dating, Environmental Radiation Monitoring, Medicine, Biology, Neutron Dosimetry, Reactor Engineering, High Level Photon Dosimetry with TL materials, standardization and inter comparison of TL dosimeters used in personnel monitoring etc.

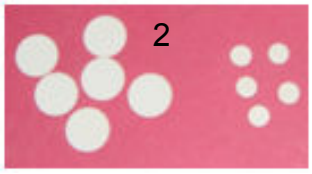
Applications in radiation oncology : Therapy machine calibration checks & inter-comparison studies with other centres, treatment planning accuracy verification using phantoms, patient specific dosimetry, studies in Brachytherapy physics, in X-ray diagnostics to determine absorbed doses to patients & in research etc.

OPTIONAL ACCESSIORIES :

A.TL Materials & Phosphors

(i) TL Phosphor $CaSO_4$: Dy Powder
(ii) TL Discs $CaSO_4$: Dy discs with Teflon base 13.5mm dia X 0.8mm thick.
(iii) LiF; Mg, Ti square chips (3.2mm x 3.2mm x 0.9mm)





B. Annealing Oven

Internal Dimensions 14 X 14 X 14 (inches)

Temp Range : upto 400° C

Temp Indication: Digital

No. of trays : 2 nos.

Heating : High grade Nichrome wire placed in the ribs of sides and bottom for uniformity.

Power requirement : Single phase 220/230VAC supply.

Accuracy : +/-1° or better

ADDITIONAL ATTACHEMENTS

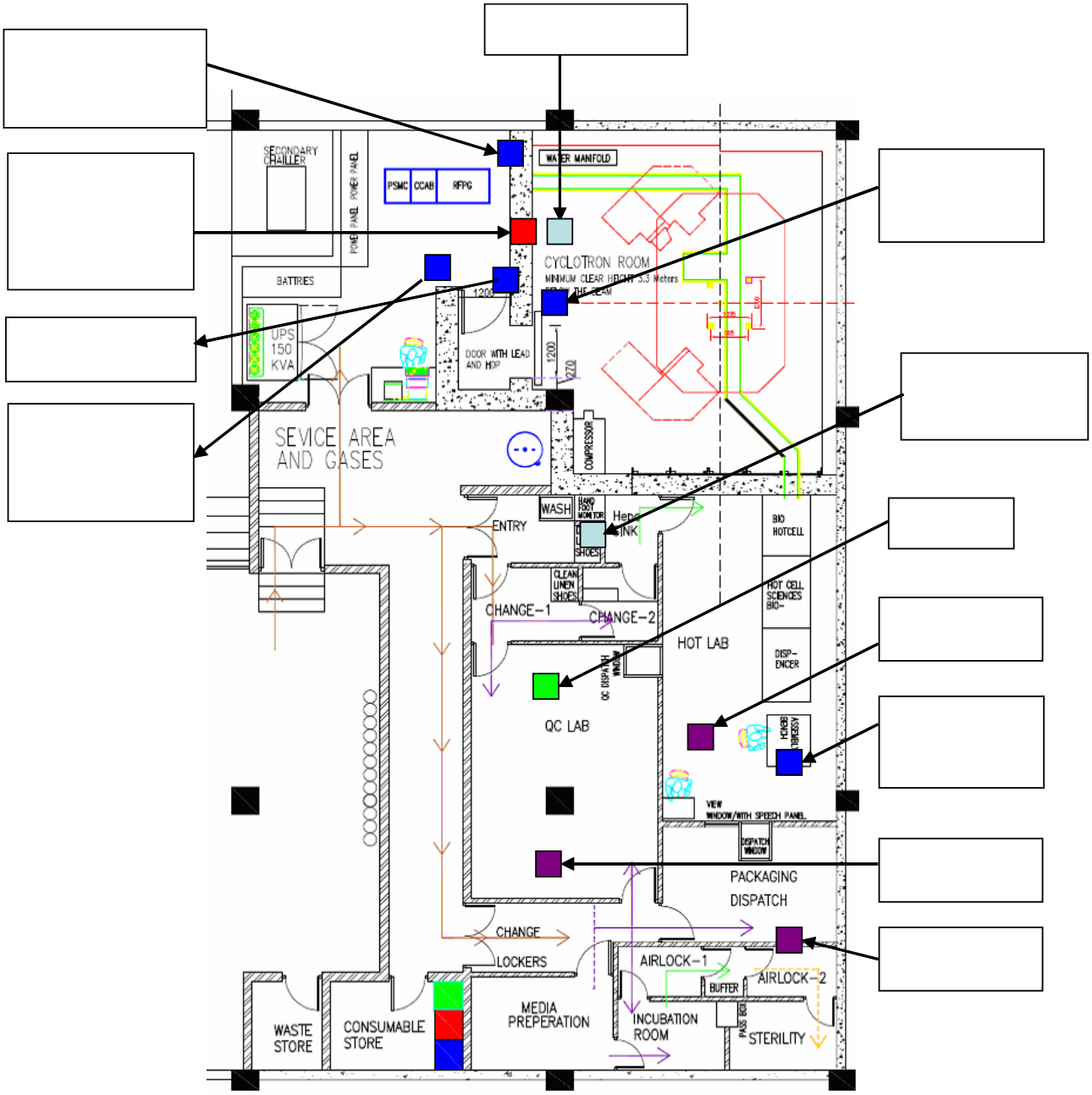
CCD SPECTROMETER: This is an optional attachemetn, which will facilitate one to record TL intensity Vs wave length in the range of 200 – 1000 nm. This CCD spectrometer is a compact portable unit roughly the size of portable hard drive. It is provided withi a fiber optic patach cable with SMA connectors, SMB – to – BNC adapter cable for external trigger signals, high speed USB cable, software etc. Software provides Graphical User interface (GUI) and can display the spectra, of TL intensity Vs wave length.

IMPORTANT SPECIFICATIONS OF CCD SPECTROMETER:

Wavelength Range : 350-700nm, 500-1000nm, 200-1000nm
Spectral Resolution : <0.5nm FWHM@ 435nm, <0.6nm FWHM@ 633nm, <2nm FWHM@ 633nm
Slit (WxH): 20µm x 2 mm
Grating: 1200 Lines/mm, 500nm Blaze, 830 Lines/mm, 800nm Blaze, 600 Lines/mm, 800nm Blaze,
Fiber Connector: SMA 905
Detector Range (CCD Chip): 350 – 1100nm, 200 – 1100nm
CCD Pixel Size: 8µm x 200µm (8µm pitch)
CCD Sensitivity: 160V / (lx.s)
CCD Pixel Number: 3648
Integration Time: 10µs – 60s
Trigger Signal: TTL, Rising Edge
Trigger Frequency, Scan Rate: Max 100Hz, 100 Scans/s[b]
Interface: Hi-Speed USB 2.0 (480 Mbit/s)

NUCLEAR INSTRUMENTATION FOR A MEDICAL CYCLOTRON PROJECT

Typical layout map of a medical cyclotron facility, where at nuclear instrumen tation of Nucleonix systems make have been installed.



Above plan indicates - cyclotron room, Hot lab, QC lab, control panel area, service area, change room, packing & dispatch area etc.

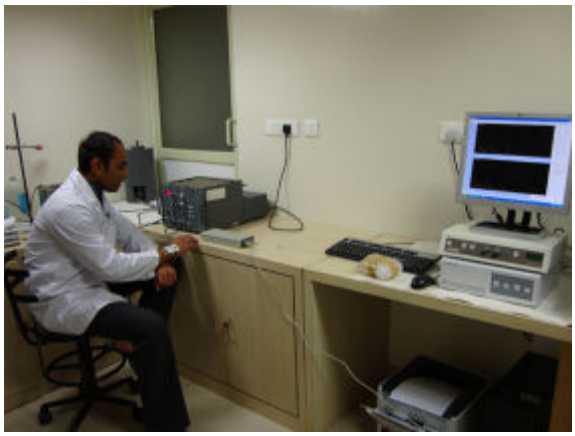
The following Nuclear Instruments and Systems are required to be installed in a medical Cyclotron facility. Details of the monitors / instruments to be installed in a location / lab are given below : Nucleonix systems can offer this total package on turn key basis to include installation, training, commissioning & maintainance. All most all the products are designed & manufactured by Nucleonix systems. Typical layout map of the a medical cyclotron facility is shown on the left side.

1	Wide Range Area Monitor	Type : WR 725A
2	Neutron Area Monitor	(Under development) Not in Nucleonix systems range at present
3	Ventillation / Duct Area Monitor	Type : GA721
4	Wide Range Area Monitor (s)	Type : WR 725 A
5	Digital Radiation Survey meter with external telepole [RADMON (Micro)]	Type : RM 703
6	Beta Gamma Hand , Foot and Clothing Monitor	Type : BM 731
7	NaI scintillation detector (well type) based Gamma Ray Spectroscopy system with 8K MCA	
8	Digital Contamination Monitor	Type : CM 710P
9	Area Gamma Monitor	Type : GA 720
11	Control Room Instrumentation	
12	Networking Software (RadGrid)	
13	Personal / Pocket Dosimeters	Type : PD71/716

Area Gamma Monitors in installed condition

Beta-Gamma Hand, Foot & Clothing Monitor in installed condition

Radiation doserate measurment with radiation survey meter (rm703) using external telepole detector arrangement



Gamma ray spectroscopy system with 8K MCA, installed in QC lab of a medical cyclotron facility, used to test isotope purity & energy of medical isotopes produced.

All the above Picutures are equipments / instruments in use at a medical cyclotron facility

I. INSIDE CYCLOTRON VAULT

1. WIDE RANGE AREA MONITOR (S) : WR 725 A : (with 20 meter long cable)
This unit covers wide range from (0.1 mR/hr to 10 R/hr) in two ranges with automatic switching between (0.1 to 100)mR/hr & (0.1 to 10)R/hr. Detector probe is kept just inside of Cyclotron Vault and through 20 meter cable, it is connected to the measuring unit situated in the control room for the convenience of monitoring. Detector probe contains two detectors inside. One detector covers Low range and the other detector covers 'HI' range. Range switchover is automatic. Refer to page no. 16 to 18 for detailed specifications.

2. NEUTRON AREA MONITOR : This is required to monitor the Neutron flux / dose rate at just inside wall of the Cyclotron Vault.
(As indicated in figure).
For this we propose to offer a **Neutron Area Monitor** with an external detector probe (Neutron). This detector probe will have 10 meter long cable between the main unit and the Electronic Monitor. One can preset alarm levels in CPS / CPM modes. This unit measures Neutron Leakage Flux in CPS/CPM mode. Measuring unit can be in the control room to facilitate centralized monitoring.
(under development with Nucleonix System)

II. EXHAUST DUCT

3. VENTILLATION / DUCT AREA MONITOR : GA 721 – (0.1 to 600) mR/hr with 30 meter cable between the detector probe to measuring unit is used for monitoring the Exhaust from the Cyclotron. This covers a range of (0.1 – 600) mR/hr. Measuring unit of GA 721 is kept in the control room for centralized monitoring. Refer to page no. 19 to 20 for detailed specifications.

III. HOT LAB NUCLEAR INSTRUMENTATION

4. SECOND * 'WIDE RANGE AREA MONITOR' : WR 725A
(0.1 mR/hr – 10 R/hr)- is to be located in this Hot Lab. Of course since this monitor is for local monitoring of the activity / dose rate(s) inside the Hot Lab, unit is kept inside Hot Lab with a short detector probe cable length. Refer to page no. 16 to 18 for detailed specifications.

5. DIGITAL RADIATION SURVEY METER WITH 1.1 METER TELEPOLE : This digital Radiation Survey meter (RM 703) has a detector fixed at the end of 1.1meter tele- pole and measuring instrument is close to the user, which enables the user to view the digital display to see the dose rates away from 1.1 meter distance.
This survey meter is specially designed with this 1.1 meter pole attachment to check for the dose rates in the Hot Cells,delivery lines,on the surface of the vials and other inaccssible areas in the cyclotron facility etc. Refer to page no. 2 to 3 for detailed specifications.

IV. ENTRY TO HOT LAB

6. BETA GAMMA HAND , FOOT AND CLOTHING MONITOR : BM 731 - is installed at the entrance / exit door to the Hot Lab. This is basically used for checking of the Contamination of Hand, Foot and Clothing of the Personnel Working in the Hot Lab to ensure that they are not contaminated and are clean at the end of the shift, before they leave the cyclotron facility. Refer to page no. 26 to 28 for detailed specifications.

V QUALITY CONTROL (QC) LAB

7. This will have an important equipment / tool namely **Gamma Ray Spectrometer, with well type scintillation detector, with 8k Multi Channel Analyser (USB) System with Software**. Refer to page no. 32 to 34 for detailed specifications.

This equipment is basically used for **identification test** and **Radionuclide Purity Test** for the Radio-nuclides such as FDG / F-18 or Tc-99, I-131 etc., produced in the medical cyclotron facility. This becomes essential tool in the QC Lab. This system will have the following constituent units.

i. MINIM based Gamma Ray Spectrometer
ii. 2" x 2" NaI Well Type Scintillation detector
iii. Gamma Reference Source Set
iv. Lead Castle for Scintillation Detector
v. 8k MCA (USB) with Personal Computer System & Data processing Software

8k MCA part of the system with software is being manufactured by Nucleonix Systems Pvt. Ltd., based on the technology received from Bhabha Atomic Research Centre (BARC), Mumbai.

8. DIGITAL CONTAMINATION MONITOR : CM 710P
This is essentially a Pancake based Digital Contamination Monitor which can be used for measuring both Beta Contamination in CPS / CPM mode and to measure low gamma dose rates up to 200 mR/hr. This use essentially to check the Contamination in QC Lab, work areas, floor space, work table, walls etc. in the QC Lab. Refer to page no. 8 for detailed specifications.

VI. PACKING SECTION

9. DIGITAL RADIATION SURVEY METER (RM 703)
This has (0 - 20)R/hr dose rate range measures dose rates in FIVE discrete ranges, which automatically switch depending upon the dose rate. Refer to page no. 2 to 3 for detailed specifications.

This equipment is used to inspect finally packed FDG other isotopes produced in packed condition kept ready for dispatch, primarily to check for any leakage radiation.

VII. AT ENTRANCE DOOR OF CYCLOTRON ROOM

10. AREA GAMMA MONITOR' : GA 720 (0.1 to 100 mR/hr) is required to be installed at the entrance door of the Cyclotron Room. This is of course installed with built-in detector probe. This is also control panel room area. Refer to page no. 13 to 15 for detailed specifications.

VIII. CONTROL ROOM INSTRUMENTATION

11. All the following Area Monitors measuring and alarm units are mounted in the Control Room for centralized monitoring. These include

i. Neutron Area Monitor
ii. Wide Range Monitor
iii. Duct Area Monitor

12. NETWORKING SOFTWARE (GAMMA LINK) is a RS 485 based networking software specially designed to interconnect all the area monitors (different types) to indicate dose rate, alarm status, alarm preset levels and fault diagnostic information centrally in a PC situated in control room. Refer to page no. 21 for detailed specifications.

Any standard P-IV computer system configuration is good enough for this software to run, on windows platform.

IX. POCKET DOSIMETERS & DOSE RECORDS DATA MANAGEMENT SOFTWARE :

The following two types of Digital Dosimeters (Pocket / waist belt worn type) are recommended for the **medical cyclotron facility** with/without dose records data management software. Digital dosimeters are essential for recording the dose taken by the personnel working in the cyclotron facility in different labs. They can check for the cumulative dose recieved at the end of the shift/day. Quantities can be decided based on the centres rquirement. Refer to page no. 22 to 25 for detailed specifications.

1. Digital Pocket Dosimeter - I - PD714
2. Digital Pocket Dosimeter - II - PD716

Dose rate data management software may be procured & used by the centre, to maintain individual dose records data of the staff at the centre, who are enrolled for personel monitoring using these Ditial Pocket Disimeters.

AVAILING OF MAINTENANCE/ CALIBRATION SERVICES AND WARRANTY CLAUSE

AVAILING OF MAINTENANCE/ CALIBRATION SERVICES AND WARRANTY CLAUSE (with in India)

GENERAL

As per the warranty clause of the company, we provide one year warranty during which period we provide free service at our works. Hence in case of any mal-function in our instruments, you are requested to send the unit back to our works by RPP/COURIER/SPEED POST PARCEL/ GATI/XPS/door delivery. We shall arrange immediate rectification/replacement within two weeks from the date of receipt of the equipment at our place. Please note that the equipment will be serviced at our works only.

The equipment is to be sent to:

The Servicing Department
NUCLEONIX SYSTEMS PRIVATE LIMITED
Plot No: 162 A & B, PHASE II, I.D.A. Cherlapally,
Hyderabad - 500 051Ph: 040-27263701/329145448/32918055
E-mail: info@nucleonix.com www.nucleonix.com

For all the Radiation monitoring equipment, detectors built-in or external probes will not have one-year warranty, but only inspection warranty at the time of supply is provided. Since detectors will / may have fragile glass construction, we do not provide warranty. In case of failure of these components, Nucleonix will supply detector replacement at cost-cost price.

Note: In respect of all types of portable radiation monitors, it may be necessary to checkup and recalibrate the equipment once in a year at our works.

EQUIPMENT REPAIRS / SERVICING POLICY (WITH IN INDIA)

During Warrantee

The following procedure is to be followed by the customers within India for availing services/ repairing facility during warrantee period.

- Equipments are to be sent to our works for availing free repair services during warrantee, after the customer receives approval from the customer support division, by sending an e-mail.
- For all equipments, costing less than 6.0 lakhs one year warrantee & free service is offered, when the equipments are sent to our works only. For larger systems such as installed systems, networked systems, specialized systems, costing more than 6.0 lakhs, free service is offered at site during one year warrantee. Field service Engineer will be deputed subject to warrantee terms & conditions.
- This does not include personal computer related problems, for which local computer service provider of the PC vendor is to be contacted. Also for software related problems, online support will be provided. Software support doesn't include cleaning of virus problems etc.

- When the equipments are sent to our works for warrantee services, they are to be properly packed with adequate cushion to prevent any transportation damages. Nucleonix Systems is not responsible for damages or loss during transportation.
- Packing / Freight charge is to be borne by customer when he sends the equipment to our works. However, when we return after servicing, packing will be Nucleonix responsibility & Freight charges will be to your account. Only services are free.
- Please indicate in your correspondence, equipment model & serial number.
- All the equipments are to be sent to our works only on door delivery basis.
- For Door Delivery Transportation, contact XPS/GATI cargo in your city / town or a reliable courier service to pick the consignment from your place. For their nearest local address & phone no's look into their websites. Transit insurance, if the customer feels is necessary, it is to be covered.
- Nucleonix Systems will not receive the equipments sent by other modes of transportation, such as Rail/Road.
- After servicing, equipments will be sent back by same mode of transport such as XPS/ GATI/COURIER/RPP.
- All types of Radiation detectors, glass ware, PMTs etc which are fragile are not covered in warrantee, if the failure is due to physical damage, external or internal due to shock, dropping, miss-handling etc. If the failure is due to a natural fault, then only it is covered under warrantee for a limited period of three months. However complete electronics is covered for 1 year warrantee.
- You can also send the equipment personally to our works for repairs either during or after warrantee, after fixing up with our service dept (Customer Support Division). If possible we may repair on same day or your person can stay for a day or two & get it repaired & or calibrated.

(b) After warrantee Services

- On expiry of 1yr warrantee, if you like to send the equipment (low cost less than 6.0 lakhs) for repairs to our works, you may please observe the following procedure.
- Send an e-mail with details mentioning that you agree to pay service charges which includes: Basic service charges per unit / module in the range of Rs: 3500 to Rs : 10,000 depending on the sophistication of the unit + calibration charges (if applicable for your equipment) + cost of components + packing charges + Return Freight charges @ actual.
- Once our customer support department responds & requests you to despatch the equipment to our works for repairs, you may do so by following the steps given below.
- Followed by this you can send the equipment straight away if it is within 5 yrs old. If the equipment is beyond 5 yrs old, then also you can send it for repairs, however only after you receive confirmation from Customer Support Division, that it is repairable & is not an obsolete model. If the design is obsolete, then customer support division (CSD) may give you 'buy back' offer to replace with new model or upgrade it with electronic circuit boards & enclosure.
- For all installed equipments costing above Rs: 6.0 lakhs, which are larger in size & for which field servicing only is recommended, you can obtain a quotation with relevant details by sending an e-mail & avail the services accordingly.

- For all field servicing jobs, since we need to depute engineers, it is likely, to take time & also it will cost more which includes Engineer's TA & DA etc., apart from basic service charges + cost of spares etc. Please note that basic service charges will be different for different products depending upon sophistication.
- Also in some cases, it may not be possible to fix-up the problems in the field itself, in such cases we may advise you to send them to our works.
- For all jobs to be serviced in the field, customer is requested to provide adequate details on the nature of problems, to enable our engineer to come prepared with adequate spares.
- For any additional information send an e-mail to info@nucleonix.com, Atten: Customer support division.

EQUIPMENT REPAIRS / SERVICING POLICY (FOR EXPORTS)

Equipments, manufactured & exported are subjected to a well defined quality assurance (QA) plan & Factory acceptance tests (FAT). Nucleonix systems has the following policy to provide maintenance support to overseas customers either directly or through international dealers / distributors.

(a) During & after warranty:

- For minor problems, which can be handled by customers, servicing tips have been provided in the user manual / servicing manual.
- Also most of the equipments have built-in fault diagnostic features which will indicate to the user nature of problem in the equipment. Based on the visual indication in the instrument Display, user can take corrective action or contact Nucleonix systems by email for help.
- Nucleonix systems will guide in localizing the defective part / module or sub-system by interacting with the customer if required. Skype will be used for communication.
- During warranty, free replacement of sub-system or board (PCB) will be done. However customer has to send defective sub-system back to Nucleonix system with-in 15 days on arranging replacement.
- During & after warranty, any Freight charges & customs clearance charges are to be borne by customers, both ways.
- If it is a manufacturing defect, then Nucleonix system will bear the replacement cost of sub-system / unit. However any Freight charges & customs clearance charges in their country are to be borne by customer.
- After warranty, services will be similar to that of services during warranty. However, customer will have to pay for cost of parts replaced, freight charges both ways & customs clearance charges in both the countries. Nucleonix Systems plans to introduce audio visuals on web or on CDs to facilitate product demonstration, installation & minor maintenance very soon.

HOW TO AVAIL CALIBRATION SERVICES (FOR INDIAN CUSTOMERS)

Nucleonix Systems offers radiation calibration services to its customers. Calibration services are provided for Nucleonix Systems manufactured products only, in general, as a company policy.

How to avail calibration services:

It is best advised that each of the Radiation monitors including Area monitors are calibrated once in a year. When you want to send your Radiation monitor / Area monitor / Contamination monitor for calibration to our works. You may send the equipment for calibration, by following the steps given below:

1. Our standard calibration charges per equipment (All types of Radiation monitors including portable survey meters, contamination monitors & Area Gamma Monitors) are Rs: 3500 + Packing + Freight charges. You can email a 'work order' accepting these charges.
2. Email your work order and despatch / send the equipment to our works if it is 5 years old or less including details of mode of transport sent with docket particulars.
3. Also mention in your work order & clearly indicate that you will agree to pay calibration charges & also equipment repair charges additionally if the unit is faulty & requires repairs before one can take it up for calibration.
4. You are requested to ensure good packing to avoid any transportation damages. Especially if there are external detector probes, they are to be packed with sufficient soft foam to ensure no damage in transportation.
5. Use only the specified following mode of transportation system for dispatching on door delivery basis: XPS/GATI cargo / Courier/RPP/Speed Post parcel etc. Send the equipment on freight paid basis. (Equipments sent by other modes such as Rail/Road etc will not be collected). Also you can cover for transit insurance both ways if you wish. Nucleonix system is not responsible for any transportation damages or loss during transportation both ways.
6. Immediately on receipt of the equipment, we will send an acknowledgement & also a proforma bill by email/ post.
7. Based on the proforma bill, once we receive the payment, equipment will be dispatched back by similar mode of transportation as mentioned above.

HOW TO AVAIL CALIBRATION SERVICES (FOR FOREIGN CUSTOMERS)

Foreign customers can calibrate Nucleonix make Radiation monitors/equipments in their country at any of their accredited Radiation calibration labs. Nucleonix systems will be happy to provide any help and guidance if needed, for calibration. Alternatively if you send the equipment here to India, we can also provide calibration services.

Calibration Standards Lab & Facility:
We have two calibration labs.

i. Low Level Calibration Lab.
ii. High Dose Rate Calibration lab.

Low Level Calibration Lab: This has a Cs-137, 165 mci standard "Gamma Survey Instruments Calibrator" from Amersham.
This calibration service has NIST Traceability standard. Calibration of all portable radiation monitors, survey meters, contamination monitors, Area monitors etc., is carried out in this lab upto 1 R/hr max dose rates.

Gamma Survey instruments calibrator has Cs-137 source 161.5 mCi as on 05 Aug 2002. It is basically a gamma survey instruments calibrator procured from AEA Technologies UK/USA. Has NIST traceability accuracy within +/- 7%.

CRC-2 camera has Co-60 standard obtained from Bhabha Atomic Research Centre, Mumbai. It is a certified source.

ANNUAL MAINTENANCE CONTRACT (AMC)

Annual maintenance contract (AMC) services:

For all sophisticated instruments & systems and also for installed monitors & networked systems in a nuclear facility or a Radiological lab or in a Medical cyclotron facility, where number of instruments are networked, it is advised that customer enters into an economical Annual maintenance contract with Nucleonix system.

Detailed AMC proposal can be obtained from our customer support division (CSD), by giving required inputs.

Inputs required by our CSD to send you AMC proposal:

- Name, year & data of purchase, Sl. Nos. of equipments, Model No's, No. of equipments for which AMC is required. Additionally number of calls per annum required for preventive & breakdown maintenance may also be indicated.

Advantage of entering into AMC:

- Equipment services offered will be prompt & timely
- Nucleonix systems maintain required spares, spare tested PCBs, detectors & other critical components which may become obsolete.
- Obsolescence in electrons is quite rapid. If you enter into AMC guaranteed service for the period of AMC will be the responsibility of Nucleonix Systems.
- Nucleonix Systems will maintain Engineers at your disposal to attend to AMC calls on time
- Without AMC, prompt service calls are not guaranteed.
- If some critical components become obsolete, then Nucleonix systems may request you to upgrade the product with new model or new electronics which may be expensive if you are not under AMC.

Training on maintenance / servicing:

- To a limited extent, we offer training on maintenance / repairs at our works to customers on chargeable basis. Details can be obtained from our customer support division, by customers who may require such services.

MANAGEMENT PROFILE & CONTACT DETAILS

MR. J.NARENDER REDDY : MANAGING DIRECTOR

Mr. J. Narender Reddy, Founder Director brings in 25 years of dedicated management and technical experience in the field of Nuclear Instrumentation and sciences. He holds a B.E. degree in Electronics and Communication Engineering from University of Mysore, M.Tech. degree in Advanced Electronics from J.N. Technological University, Hyderabad.

He has worked for "Electronics Corporation of India Limited", an Establishment of Department of Atomic Energy for about 9 years in the field of Nuclear Instrumentation. He founded Nucleonix Systems Pvt Ltd (NSPL) in the year 1990, and has been responsible for the growth of NSPL over the last few decades into a committed, well-known and respected organization in the field of Nuclear instrumentation in India with a strong R&D and technical support team. He has seen through several projects and has been responsible for indigenous design & development of several first-of-its-kind products in India conforming to international standards.

He brings business acumen and industry knowledge that covers solutions for Nuclear Education / Research, Nuclear Power, Cancer Hospitals, Nuclear Industrial applications, Mining, Steel, Defense and other segments.

He is a Life member in Scientific & Professional bodies such as: Indian Society for Radiation Physics (ISRP), Indian Association for Radiation Protection (IARP), Indian Nuclear Society (INS), Association of Medical Physicist of India (AMPI), Luminescence Society of India (LSI) & National Association for applications of Radioisotopes & Radiation in Industry (NAARRI) etc.

He has presented more than ten technical papers in various National Symposia / Seminars and workshops, conducted by Department of Atomic Energy establishments such as Bhabha Atomic Research Centre, Indira Gandhi Centre for Atomic Research and other universities and research establishments in the country. He has international business experience in working with clients and suppliers from various parts of Asia, USA and Europe.

MR. J.DHEERAJ REDDY, DIRECTOR (TECHNICAL)

Mr.J. Dheeraj Reddy has over 12 years of technical expertise in Research & Development of several products while working for NSPL. He holds a Bachelor's degree in Electronics & Communication Engineering from J.N. Technology University, Hyderabad.

Since joining NSPL in 1999, he has significantly contributed to the development of many new products for the DAE, Defense, Hospitals, Nuclear Education segments. His contribution in system design, hardware and firmware design has led to rapid product developments across various market segments in a short span of time. He has developed innovative and first-of-its-kind instruments in the country. He has authored/co-authored about seven-eight technical papers in Nuclear Instrumentation presented in various seminars / symposia across the country.

MR. J. NISHANTH REDDY, DIRECTOR (I.T)

Mr. J. Nishanth Reddy brings 12 years of business management and technical experience built upon a solid educational foundation. He earned an MS in Nuclear Engineering from University of Michigan, Ann Arbor, USA and a BS in Instrumentation Engineering from Osmania University, Hyderabad, India. He has led several large-scale software / embedded development projects where he has operated in the roles of Project Manager, Lead Business Analyst, Chief Systems/Software Architect.

Mr.Nishanth is the founder/co-founder of multiple companies – Elite Force Ltd, USA, Nucleonix Biometric Solutions Division, India, NxID Conin Technologies, India. He is the founder trustee of 2 Social service organizations – "Dharma Seva" and "Young India".

At Nucleonix Systems Pvt Ltd, he has been playing an important role in Exports & Business development, Software and internal processes & planning. He has presented two international technical papers. He has international business experience in USA, Africa and Asia.

CONTACT DETAILS

a) Marketing Manager : Bhaskara I.V.
Tel : 91-40-27263701, 32918055, 32914548.
Mobile : + 93935 04552
Email : info@nucleonix.com

Contact Marketing Manager for all Sales / servicing and Technical information including customer support related issues.

b) Director: Mr. J. Dheeraj Reddy
Email: jdreddy@nucleonix.com
Mobile No. +91-93470-54812

Contact him for : Any Technical Information and clarifications on products, which cannot be answered by General Manager / Customer support division.

c) Head, Information Technology, Business Development & projects
Director: Mr. J. Nishanth Reddy
Email: nishureddy@yahoo.com; info@nucleonix.com
Mobile No. +91-9701133113

For any deficiencies in products include software issues & lapses in services by Nucleonix staff / Engineers or by other management, Customers can register their complaint by email to the Head IT / Business development or Managing Director, of the company, to address their problems / issues. This will help the company to serve you better.

d) Managing Director: Shri. J.NARENDER REDDY
Email : jnreddy@nucleonix.com; info@nucleonix.com

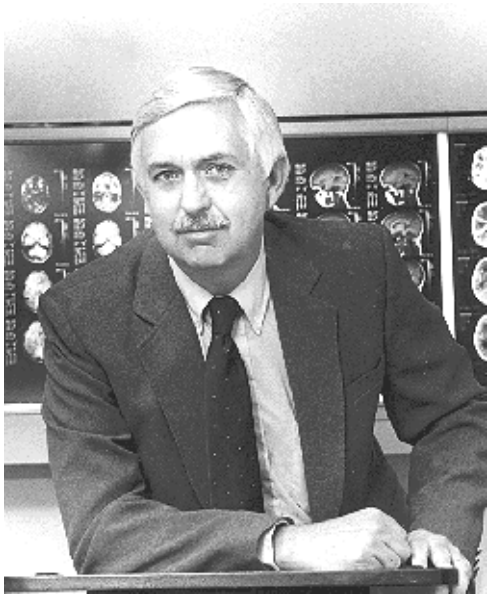
Contact Managing Director for : Foreign relations, International Business co-operation, Joint ventures, Exports, Dealership in other countries, Policy matters, Technology tie-ups etc.

RADIATION QUANTITIES AND UNITS

Radiation Quantities and Units

(Reproduced with the permission from Dr. Perry Sprawls)

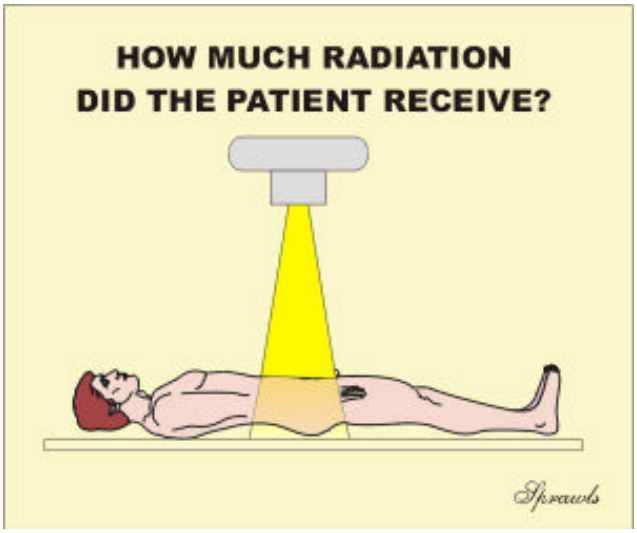
Perry Sprawls, Ph.D., PE
(FACR, FAAPM, DADR, DABMP, CCE)
Physicist, Engineer, Educator Emory
University Faculty
1960 - 2005

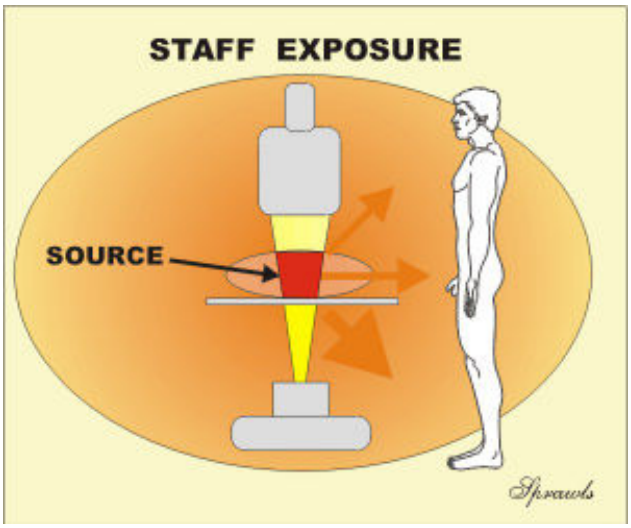


Introduction and Overview

Several forms of ionizing radiation are used in medical imaging. Even though the risk is low, if there is a risk at all, it is appropriate to manage the radiation delivered to patients being imaged and to use only sufficient radiation to produce the necessary image quality. The question we begin with is: How much radiation is delivered to a patient's body? As we are about to see, that is not always an easy question to answer. There are several factors contributing to the complexity. They include the many quantities that can be used to express the amount of radiation, the different units that are used, and the generally uneven distribution of the radiation within the patients body.

Also, some medical imaging procedures expose the staff to radiation. It is necessary to determine their exposure so that the risk can be managed in the context of ALARA programs.



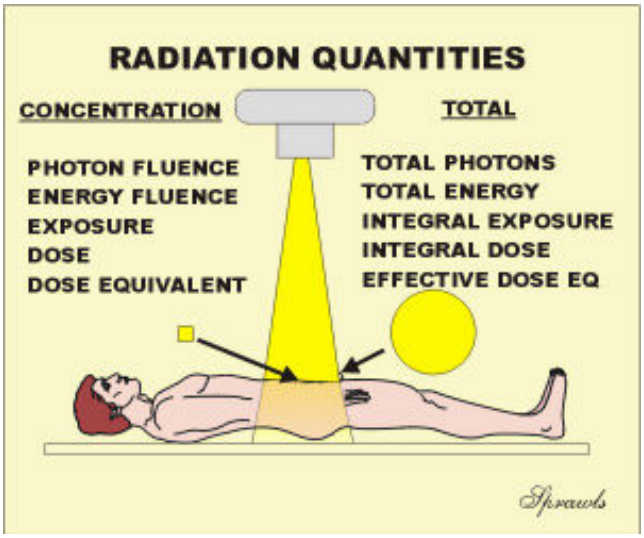


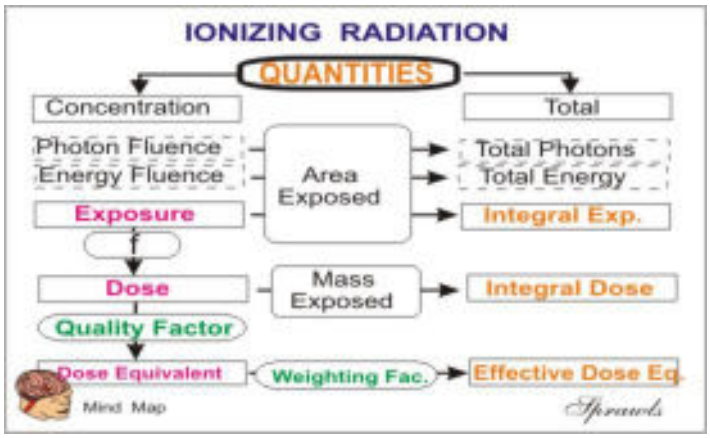
Determining and expressing the radiation to the staff and other persons in an imaging facility is also somewhat complex because of the reasons mentioned above.

Radiation Quantities

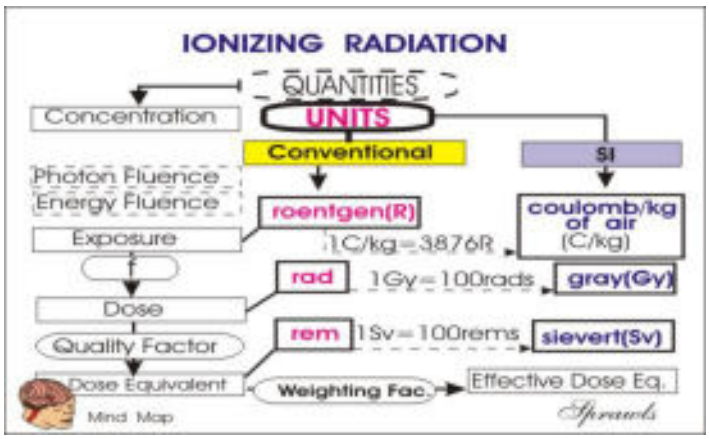
As we see below, there are many different physical quantities that can be used to express the amount of radiation delivered to a human body. Generally, there are both advantages and applications as well as disadvantages and limitations for each of the quantities. There are two types of radiation quantities: those that express the concentration of radiation at some point, or to a specific tissue or organ, and there are also quantities that express the total radiation delivered to a body. We will be considering each of these quantities in much more detail.

The general relationship between the concentration and total radiation quantities are illustrated below.





Radiation Units



Throughout the course of history there have been many different systems of units developed to express the values of the various physical quantities. In more recent times the metric system has gradually replaced some of the other more traditional or classic systems. This is also true for the units used for many of our radiation quantities.

Conventional Units

During the relatively short era (just over one century) of medical applications of ionizing radiation, a variety of radiation units were developed. We will refer to these as the conventional units. These are such units as the "three Rs", the roentgen, rad, and rem. All of these were very practical units and have served their purpose well. However, they did not fit into the metric system of units, specifically the Système International d'unités (SI units) that is being promoted for the sake of having one unified system of units for all physical quantities.

SI Units

The SI radiation units have been adopted by most organizations and publications. However, because of their practicality and familiarity, some of the conventional units, especially the roentgen, will continue to be used by many.

With respect to the two systems of units, we are faced with the necessity of recognizing and understanding the different units, and make conversions between the two systems when necessary.

Specific Quantities and Their Associated Units

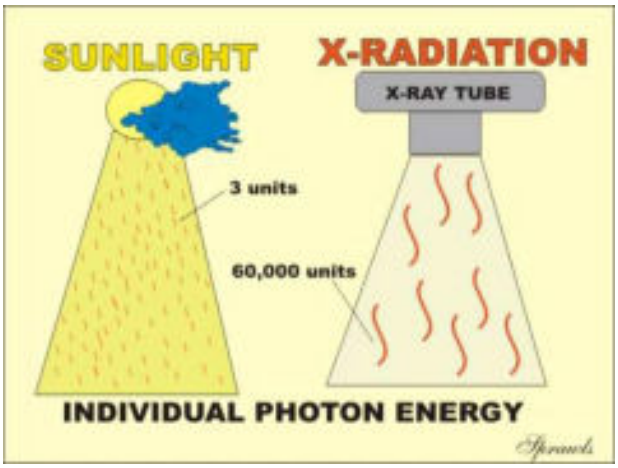
We will now consider each of the radiation quantities and their associated units in detail. As an overview, they are listed below showing if there are concentration or total radiation quantities.
NOTE: You can jump to the discussion of any quantity by clicking on it's name below.

Radiation Concentration	Total Radiation
Photon Concentration (Fluence)	Total Photons
Energy Concentration (Fluence)	Total Energy
Exposure (Entrance Surface Exposure)	Surface Exposure Integral
Air Kerma (Kinetic Energy Released per unit MAss)	Dose Area Product
Absorbed Dose	Integral Dose
Mean Glandular Dose (Mammography)	
Computed Tomography Dose Index	Dose Length Product
Equivalent Dose	Effective Dose

Photons

Let us recall that all forms of electromagnetic radiation (light, x-ray, gamma, etc) are actually packaged and delivered in the form of many many small units of energy, the photons. As we have already discovered in a previous module, the physical difference between the different types of radiation, like light and x-rays, is the amount of energy packaged in each photon. Therefore, it is logical to consider expressing the amount of radiation delivered to an object, such as a human body, in terms of either the total number or the concentration of the photons. This turns out to not be the most practical approach. There are several reasons. One is that the number of photons in a typical x-ray beam is such a large number, like in the billions or more, that it is not a practical quantity to work with. Another reason is that, especially in x-ray beams, we do not have practical instruments for counting those large quantity of photons. As we will see, it is more practical to measure some other quantities that we will meet later.

It is very helpful to our understanding of radiation to see it as a shower of photons, even if we do not usually quantify the radiation in that manner. However, in medical imaging there are two situations in which we are concerned with the number of protons.



Total Photons, A Measure of Radioactivity

One method used to measure the radioactivity of a sample is to count the photons that are emitted. Then, with proper calibration factors, the counts per minute (CPM) can be converted into units of radioactivity, curies or becquerels.

Photon Concentration (Fluence), A Factor in Image Quality

In all forms of medical imaging using ionization radiation (x-ray, gamma, etc) the concentration of photons absorbed in the image forming process is a very critical factor. As described in another module, this is the principle factor that determines the amount of visual noise in the image. That is the so-called quantum (photon) noise. As we will learn later, the image noise is decreased by increasing the photon concentration. In projection imaging (radiography, fluoroscopy, gamma camera) the critical quantity is the concentration (photons/unit area) absorbed by the image receptor that determines the noise level.

In CT, it is the concentration of photons absorbed in each tissue voxel that determines the noise.

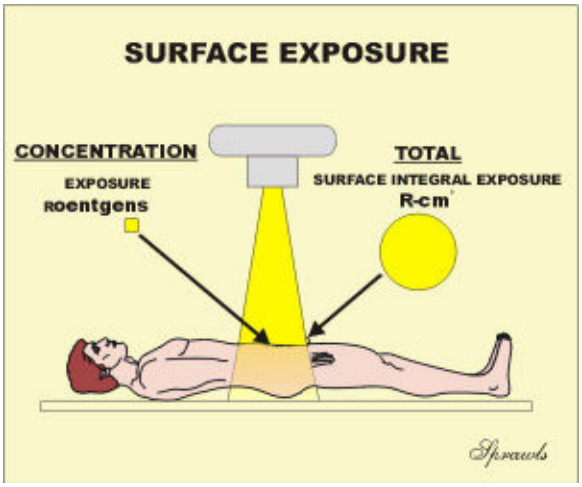
So, photon concentration (fluence) is an important factor in producing good quality images.

Energy

The radiation used for all types of medical imaging deposits energy in the patient's body. This happens when the radiation (which is energy) interacts with and is absorbed by the tissues. Since energy is one of the fundamental physical quantities, it is logical that this would be an appropriate quantity for expressing the amount of radiation delivered to a body. This is done, but the quantity is usually not called energy. As we are about to see, the concentration of energy absorbed in tissue is the quantity, Absorbed Dose , and the total energy absorbed in a body is the Integral Dose . We will come back to these quantities later, but it is appropriate to consider some other quantities before we do.

Exposure

Exposure is a radiation quantity that expresses the concentration of radiation delivered to a specific point, such as the surface of the human body.We need to emphasize that this expresses only the concentration at some specified point. Knowing the exposure tells us nothing about the total radiation imparted to a body. This can be expressed by several quantities, the first that we will consider is the Surface Integral Exposure (SIE) . We will come back to this after developing more of the details of the quantity, Exposure .



There are two units for expressing Exposure. The conventional unit is the roentgen (R) and the SI unit is the coulomb/kg of air (C/kg of air). Now lets find out where these units cam from and their relationship. It goes back to the early days of x-radiation when it was discovered that one of the effects of radiation was that it ionized air. As it turned out, this was a very practical way of detecting and measuring radiation. The procedure is to expose a small volume of air contained in an ionization chamber to the radiation and then measure the amount of ionization that was produced in the air. This is relatively easy to do because the ionization affects the electrical conductivity of the air and can be measured with an electrometer. Because of this method of measurement, the unit, the roentgen, is officially defined in terms of the amount of ionization produced in a specific quantity of air.

The ionization process produces an electrical charge that is expressed in the unit of coulombs. So, by measuring the amount of ionization (in coulombs) in a known quantity of air the exposure in roentgens can be determined. The relationship is:

1 R = 2.58 x 10-4 C per kg of air

Most of us do not need to get involved with this relationship because most ionization chamber instruments are calibrated to readout directly in roentgens.
Now a question, what is wrong with the roentgen as a unit for expressing exposure? My opinion is that there is not anything wrong with it. It is a great unit that is well established and very practical. It is just about the right size for expressing exposure values encountered in medical imaging and it has a very convenient relationship to absorbed dose in rads for most soft tissues. It also honors the physicist who gave birth to medical imaging.
The opposition to the roentgen as a unit is that it is not a whole number, it is a fraction of a C/kg of air.

The SI unit for exposure is the C/kg of air.

This is a very awkward unit and not very practical but it is "pure" and fits into the SI scheme.

From time to time we might find it necessary to convert between the two units. The conversion is:

1 C/kg of air = 3876 R

The usual and appropriate use of the quantity, exposure, is to express the concentration of radiation delivered to a specific point, such as the Entrance Surface Exposure for a patient. Although knowing the surface entrance exposure to a patient does not give a complete description of the radiation delivered to all tissues, it does provide useful information for several purposes. Entrance Surface Exposure values can be used to:

- Compare different imaging techniques with respect to radiation delivered to patients, especially for the same anatomical coverage.
- Calculate the absorbed dose to underlying tissues and organs.

Air kerma

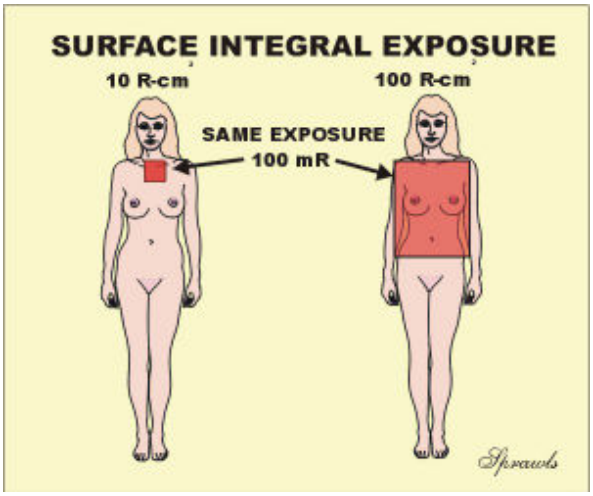
Air kerma is another radiation quantity that is sometimes used to express the radiation concentration delivered to a point, such as the entrance surface of a patient's body. It is a quantity that fits into the SI scheme.
The quantity, kerma, originated from the acronym, KERMA, for **Kinetic Energy Released per unit MAss (of air). It is a measure of the amount of radiation energy, in the unit of joules (J), actually deposited in or absorbed in a unit mass (kg) of air. Therefore, the quantity, kerma, is expressed in the units of J/kg which is also the radiation unit, the gray (G) . A little later we are going to discover that the concentration of radiation energy absorbed in a material is actually the radiation quantity, Absorbed Dose , but more on that later. At this time we just need to recognize that air kerma is just the Absorbed Dose in air.**

The quantity, air kerma, has two things going for it and is beginning to replace the quantity, exposure, for expressing the concentration of radiation delivered to a point, like the entrance surface to a human body (patient or staff).

1. It is easy to measure with an ionization chamber. Since the ionization produced in air by radiation is proportional to the energy released in the air by the radiation, ionization chambers actually measure air kerma as well as exposure. An ionization chamber can be calibrated to read air kerma, or a conversion factor can be used to convert between air kerma and exposure values.
2. It is expressed in a practical metric SI unit. Air kerma (energy released in a unit mass of air) is expressed in the units of joule per kilogram, J/kg. This is also the unit gray, Gy, used for absorbed dose. Here is the easy part. If we know air kerma measured (or calculated) at a point where soft tissue is located, the absorbed dose in the tissue will be just about equal to the air kerma.

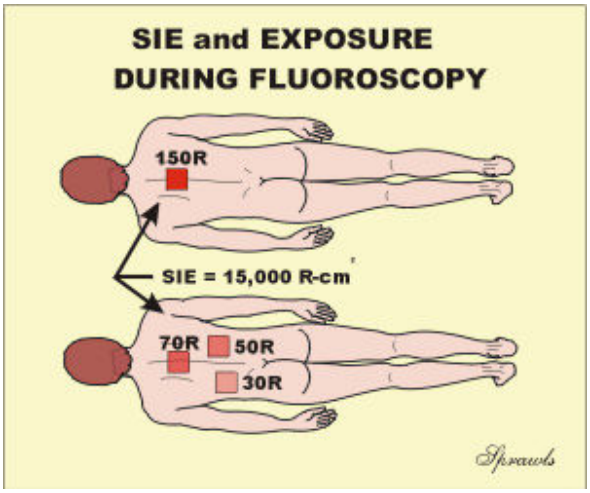
Surface Integral Exposure

Up to this point, we have been considering quantities and units that can be used to express the concentration of radiation delivered to some location, such as the surface of a body. The four quantities were: energy fluence, photon fluence, exposure, and air kerma. While each of these quantities have useful applications, they are very limited in that they do not give information on the total radiation delivered to a body. For that we now turn to several other quantities.



The first is the Surface Integral Exposure (SIE) that is illustrated here. The concept is simple. If we have a uniform exposure over some area of a body, then the SIE is just the product of the exposure value (mR) and the size of the exposed area (cm2). The unit for SIE is the R-cm2. Note: it is not R/cm2, it is the product. An alternate name that is sometimes used for this quantity is Exposure Area Product. When the exposure is not uniformly distributed over the exposed area , like in the fluoroscopic example coming up, the SIE is the sum (or integral) of the individual area and exposure products for the entire body. The value of the SIE compared to just surface entrance exposure, is that it gives information about the total radiation (not just concentration) delivered to a body. Generally, the risk of the stochastic effect, cancer induction, is probably related, to some degree, to the total radiation to a body. Consider the two patients shown here. Both received the same exposure, 100mR. But did they both receive the same amount of radiation? The exposure to the lady on the right was to a much larger area of her body. She received an SIE of 100 R-cm2 compared to only 10 R-cm2 for the lady on the left. Here is a good example of where just knowing the exposure (100 mR), dose not tell the full story.

Fluoroscopy provides another good application to compare the use of SIE and Exposure. Let's consider these two patients. Both received the same SIE, 15,000 R-cm2 because the fluoroscopic time was the same. Now the question is, did they receive the same surface exposure? The difference is that for the upper patient, the x-ray beam was not moved during the procedure and all of the radiation was concentrated in one area. This produced a relatively high exposure of 150 R to that area. During the procedure for the lower patient, the beam was moved to several different areas. This distributed the radiation so it was not all concentrated in one area. So, which quantity, exposure or SIE, provided the most information? It depends on what type of risk is being considered. The stochastic risk of cancer is probably more related to the SIE. The risk of skin burning is more related to exposure, that is the concentration of the radiation.



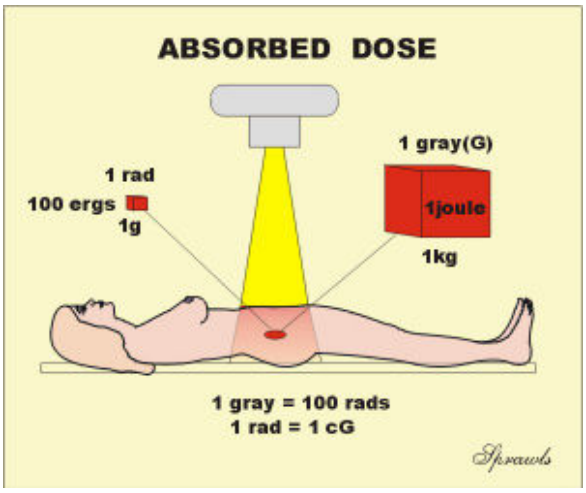
Dose Area Product

Dose Area Product (DAP) is similar in concept to surface integral exposure and exposure area product in that they all express total radiation delivered to a patient. The principle difference is in the units used. DAP is in dose units, such as Gy-cm2. For a uniformly exposed area, the DAP is just the product of the air kerma ,in Gy or mGy, and the exposed area in cm2. DAP provides a good estimation of the total radiation energy delivered to a patient during a procedure.

Both radiographic and fluoroscopic machines can be equipped with devices (DAP meters) or computer programs that measure or calculate the DAP for each procedure. It is the most practical quantity for monitoring the radiation delivered to patients.

Absorbed Dose

Absorbed Dose is the radiation quantity used to express the concentration of radiation energy actually absorbed in a specific tissue. This is the quantity that is most directly related to biological effects. Dose values can be in the traditional unit of the rad or the SI unit of the gray (Gy). The rad is equivalent to 100 ergs of energy absorbed in a gram of tissue and the gray is one joule of energy absorbed per kilogram of tissue.



The conversion between the two units is easy (if you get the decimal point correct!).

1 gray (Gy) = 100 rads

10 mGy = 1 rad

1 mGy = 100 mrad

The quantities relating to radiation outside of a human body, such as exposure, air kerma, SIE, and DAP, are relatively easy to measure because a measuring devise, ionization chamber or DAP meter, can be placed at the location of interest. However, absorbed dose in tissue cannot be measured directly by any practical methods. Dose measuring devices, dosimeters, can be placed on the surface, but it is generally not reasonable to insert them into most internal tissues or organs. The absorbed dose in most body tissues is usually determined by indirect means.

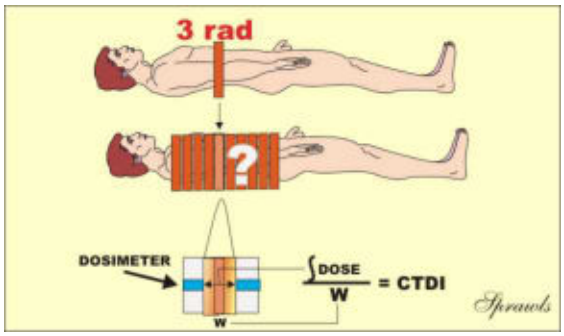
A common method is to first determine the entrance surface exposure, or air kerma, over the tissue or organ of interest and then use published dose factors to calculate the dose in a specific tissue location. The dose to the breast tissue in mammography is determined by this method and will be discussed more later.

Another method used to determine dose is to actually measure the dose in a "phantom". A phantom is a block of some material (usually plastic or water) that has the same radiation absorption properties as tissue. The phantom should be approximately the same size and shape as the body section in which the dose is to be determined. A dosimeter is inserted into the phantom and it is then exposed to radiation using known exposure factors. These measured dose values in the phantom can them be used to estimate patient dose values by applying appropriate factors to account for different exposure conditions.

It is not always easy to determine the absorbed dose to a specific tissue location or organ in a patient undergoing an imaging procedure. There are several complicating factors, including variations in organ size and location, variations in body size and composition, and the non-uniformity of the radiation distribution within the body. To overcome some of these difficulties several special radiation dose quantities have been developed for specific imaging procedures, such as CT and mammography. These special quantities make it possible to determine a dose value that is a reasonable estimate of the "true dose" that is actually delivered to the tissue. These special dose quantities are usually determined by following well established measurement and calculation protocols. This makes it possible to compare dose values for different imaging techniques, among institutions, and from country to country. We will now look at tow of these special quantities.

Computed Tomography Dose Index

The Computed Tomography Dose Index, CTDI, is the special dose quantity that is used extensively to express absorbed dose in CT.



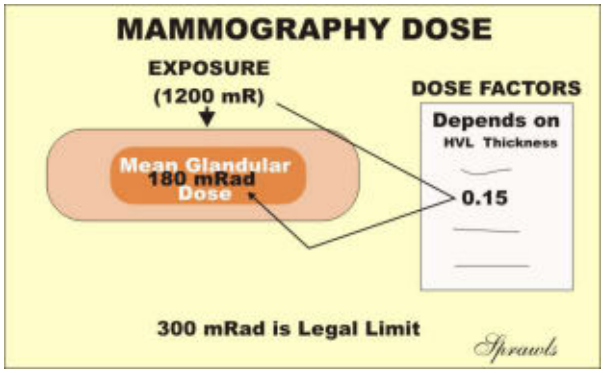
Let's recall that in CT the x-ray beam is rotated around the patient and passes through from all sides. This gives a relatively uniform distribution of absorbed dose within each slice. A dose value determined at the center of the slice is usually considered a good indicator of tissue dose and can be used to compare imaging techniques and for dose management purposes. One of the complicating factors in determining CT dose is that the tissue in a slice is exposed to two sources of x-radiation. One is the direct beam and the other is the scattered radiation from adjacent slices in the typical multiple slice imaging procedure. It is the contribution from the scattered radiation that is very difficult to measure. Values for the CTDI are determined by a measuring protocol that makes a reasonable estimate of the dose contribution from scatter. The typical procedure is illustrated above. A pencil shaped dosimeter (ionization chamber) is placed in a phantom. It is then scanned for only one complete slice and the dose value is read. The dosimeter will read the radiation from the direct x-ray beam within the slice plus the scattered radiation coming out of the sides of the slice and reaching the dosimeter. Here is a somewhat subtle but crucial point: the concept of the CTDI is based on the assumption that the scatter measured from a single slice, as just described, is a good estimate of the scatter into a slice from adjacent slices in a multiple-slice scan. This procedure does provide a good approximation of the actual dose, but since it is not completely precise, it is called a dose index.
The CTDI can be measured at points other than the center of a slice, if that information is needed.

Mammography Mean Glandular Dose

The Mean Glandular Dose (MGD) is the special dose quantity used in mammography. It is defined as the mean, or average, dose to the glandular tissue within the breast. The assumption is that the glandular tissue, and not the fat, is the tissue at risk from radiation exposure. Obviously, it is just about impossible to determine the actual dose to the glandular tissue during a specific mammographic procedure because of variations in breast size and distribution of glandular tissue within the breast. The MGD is based on some standard breast parameters.

MGD values are determined by following a standard two-step protocol.

1. The first step is to determine the entrance surface exposure, or air kerma, to the breast. This can be measured directly with small dosimeters placed on the breast or calculated from the know calibration factors for the mammography equipment.
2. Then, the MGD is determined by multiplying the surface exposure value by published dose factors. The dose factor values are tabulated according to breast size and composition and the penetrating characteristics of the x-ray beam as determined by the anode material, filtration, and KV.



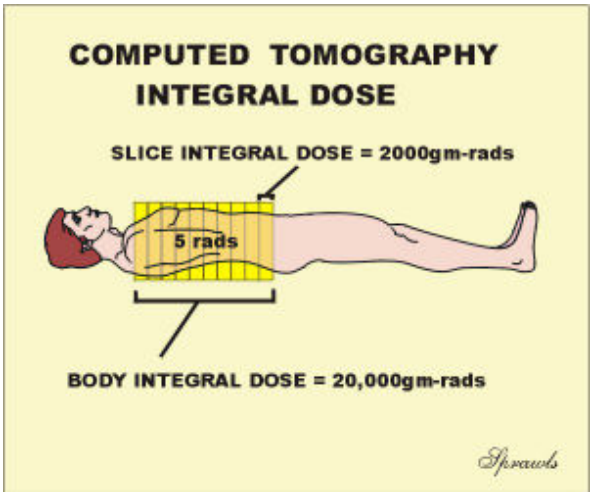
For comparison of imaging techniques, evaluation of equipment performance, general dose management, and regulatory and accreditation purposes, the MGD to a "standard" breast is used. The standard is a 4.2cm thick compressed breast consisting of 50% glandular tissue and 50% fat. This corresponds to the standard phantom that is used for image quality evaluation and comparative dose determinations.

Integral Dose

As we have just observed, absorbed dose, including the special dose quantities; CTDI and MGD, all describe the concentration of radiation energy absorbed in tissue. The units were the gray (1 joule/kg) or the rad (100 ergs/gm) of tissue. While knowing the dose to a specific tissue location or organ is often valuable information, it does not tell the full story about how much total radiation energy is deposited in a body. Integral dose is the radiation quantity that is equal to the total energy absorbed by the body.

The SI unit for integral dose is the joule (the standard unit of energy), and the conventional unit is the gram-rad. Let's now use this CT illustration to distinguish between the two quantities, dose and integral dose, and do it with a question. Let's assume that first the patient was scanned for just one slice, and the dose to the slice was 5 rads. Now, the scanning was continued to include a total of 10 slices. Now the question...what was the dose to the patient for the 10-slice scan? Are you going to say 50 rads? Let's think about it. Remember dose is a concentration of absorbed radiation energy. When the additional 9 slices were scanned, covering different tissue, it did not change the concentration (dose) to the tissues, it just exposed more tissue with the same dose, 5 rads. Therefore, when the number of slices was increased, the integral dose, or total energy absorbed in the body, was increased, but the absorbed dose (concentration) was not.

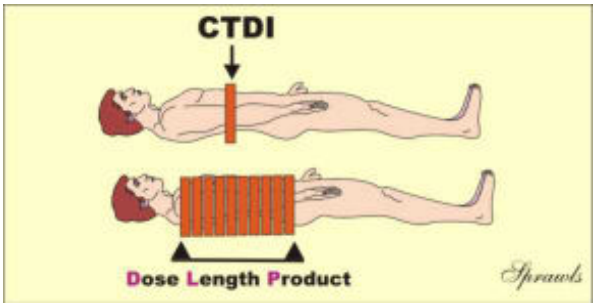
It is generally assumed that the risk of cancer induction is related to the integral dose because it takes into account the amount of tissue exposed.



Computed Tomography Dose Length Product

We recall that the CTDI is the practical quantity for specifying dose in CT procedures. The associated quantity for specifying the "total radiation" to a patient is the dose length product (DLP) as illustrated here.

The DLP is just the product of the CTDI value and the length of the body area scanned. It has the units of either rad-cm or Gy-cm. It is a useful and practical quantity for comparing the total radiation to patients for various CT procedures. It is however, not a precise measure of the total radiation or integral dose, that is more difficult to determine.



Dose Equivalent

All of the quantities that we have discussed up to this point have been physical quantities. That is they are quantities that can be measured and expressed in terms of the more fundamental physical quantities like energy. However, a major reason for determining the amount of radiation delivered to a body is to relate it to biological effects or the biological impact of the radiation on the body. This brings another factor into consideration. That is various types of radiation might not produce the same biological impact, even when the dose or energy delivered to the tissue is the same. In other words, just knowing the (physical) dose does not tell the whole story.

Dose Equivalent, in the unit, sievert (Sv), is a quantity that expresses the relative biological impact of the radiation by including a radiation weighting factor (wR). The relationship is:

$$\text{Dose Equivalent (Sv)} = \text{Dose (Gy)} \times wR$$

The value of the radiation weighting factor (wR) is a characteristic of each specific type of radiation. What makes it easy is that the radiations we use for medical imaging (x-ray, gamma, beta, positron) all have radiation weighting factor (wR) values of one (1). Therefore, for our types of radiations:

$$\text{Dose Equivalent (Sv)} = \text{Dose (Gy)}$$

Some other types of radiation, like the larger particles, might have higher values for wR. What this means is that these radiations will produce more biological effect per unit of absorbed dose.

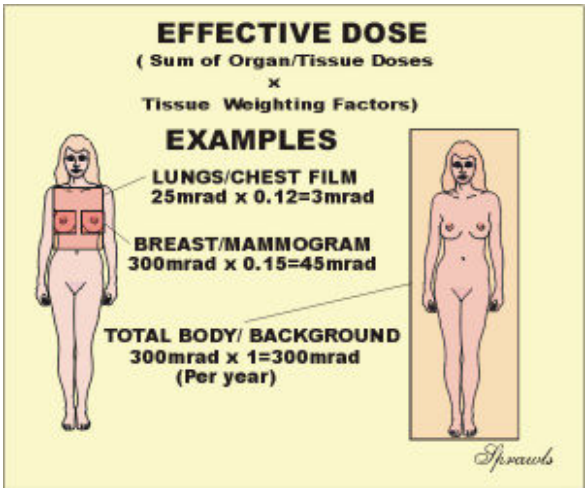
Where we will most often encounter dose equivalent is in expressing the radiation received by personnel working in radiation environments, etc. For example, the values measured with personnel monitoring devices (film badges, TLDs, etc) are usually reported in sieverts.

Effective Dose

Effective dose is becoming a very useful radiation quantity for expressing relative risk to humans, both patients and other personnel. It is actually a simple and very logical concept. It takes into account the specific organs and areas of the body that are exposed. The point is that all parts of the body and organs are not equally sensitive to the possible adverse effects of radiation, such as cancer induction and mutations.

For the purpose of determining effective dose, the different areas and organs have been assigned tissue weighting factor (wT) values. For a specific organ or body area the effective dose is:

Effective Dose (Gy) = Absorbed Dose (Gy) x wT



f more than one area has been exposed, then the total body effective dose is just the sum of the effective doses for each exposed area. It is a simple as that. Now let's see why effective dose is such a useful quantity. There is often a need to compare the amount of radiation received by patients for different types of x-ray procedures, for example, a chest radiograph and a CT scan. The effective dose is the most appropriate quantity for doing this. Also, by using effective dose it is possible to put the radiation received from diagnostic procedures into perspective with other exposures, especially natural background radiation.

It is generally assumed that the exposure to natural background radiation is somewhat uniformly distributed over the body. Since the tissue weighting factor for the total body has the value of one (1), the effective dose is equal to the absorbed dose. This is assumed to be 300 mrad in the illustration.

Let's look at an illustration. If the the dose to the breast ,MGD, is 300 mrad for two views, the effective dose is 45 mrad because the tissue weighting factor for the breast is 0.15.
What this means is that the radiation received from one mammography procedure is less than the typical background exposure for a period of two months.

Tissue Weighting Factors

Tissue	Weighting Factor
Gonads	0.25
Breast	0.15
Red Bone Marrow	0.12
Lung	0.12
Thyroid	0.03
Bone Surface	0.03
Remainder	0.3 (For the remaining organs a value of 0.06 is used for each of the five organs receiving the highest dose.)
Total Body	1.0

ADDITIONAL DEFINITIONS OF RADIATION UNITS

- **Absorbed dose :** The energy transferred to a material by ionising radiation per unit mass of the material.
  Unit : J kg^{-1}; Name of unit : Gray (see also Rad)

- **Activity :** Measurement of quantity of radioactive material. It is the number of nuclear transformations or isomeric transitions per unit time.
  Unit : s^{-1} Name of unit : Becquerel (see also Curie)

- **Alpha decay :** A radioactive conversion accompanied by the emission of an alpha particle. In alpha decay the atomic number is reduced by 2 and the mass number by 4. Alpha decay occurs, with a few exceptions, only for nuclides with a proton number exceeding 82.

- **Alpha radiation :** Radiation that consists of high energy helium (^4He) nuclei emitted during alpha disintegration of atomic nuclei. Alpha particles possess discrete initial energies (line spectra) which are characteristic of the emitting nuclide.

- **Becquerel (Bq) :** Name of the derived SI unit of activity. Number of radioactive transformations or isometric transitions per seconds s^{-1} = Bq.

1 Bq	=	27×10^{-12} Ci	=	27 pCi
1 kBq	=	27×10^{-9} Ci	=	27 nCi
1 MBq	=	27×10^{-6} Ci	=	27 μCi
1 GBq	=	27×10^{-3} Ci	=	27 mCi
1 TBq	=	27 Ci	=	27 Ci

- **Beta decay :** Radioactive conversion accompanied by the emission of a beta particle, i.e. a negatively charged electron (b^- decay) or a positively charged electron ((b^+ decay). When a negatively charged electron is emitted, a neutron in the atomic nucleus is converted to a proton with the simultaneous emission of an antineutrino, so that the proton number Z is increased by 1. When a positively charged electron (positron) is emitted, a proton in the nucleus is converted to a neutron with simultaneous emission of a neutrino, so that the proton number **Z** is decreased by 1.

- **Beta Radiation :** Radiation that consists of negative or positive electrons which are emitted from nuclei undergoing decay. Since the decay energy (or, if it is followed by gamma radiation, the decay energy less that photons energy) is statistically divided between beta particles and neutrinos (or antineutrinos), the energy spectrum of beta radiation is continuous, extending from zero to a maximum value characteristic of the nuclide concerned. The maximum beta energy is generally termed the “beta end-point energy of the nuclide”.

- **Bremsstrahlung :** Radiation that results from the acceleration/deceleration of charged particles in the Coulomb field of atoms.

- **Curie (Ci) :** Name for derived unit of activity. One Curie corresponds to 3.7×10^{10} nuclear disintegrations or isomeric transitions per second 1 Ci = 3.7×10^{10} s^{-1}.

  1 Ci = 37 GBq
  1 mCi = 37 mBq
  1 μCi = 37 kBq
  1 nCi = 37 Bq
  1 pCi = 37 mBq

- **Dose :** See absorbed dose, exposure value, and dose equivalent

- **Dose equivalent :** A term used in radiation protection for the radiation dose. It is the product of absorbed dose times the quality factor.
  Unit : J kg^{-1}; Name of unit: Sievert (see also Rem)

- **Dose rate :** Dose absorbed per unit time

- **Electron radiation:** Particle emission consisting of negatively or positively charged electrons.

- **Exposure dose:** The ratio of the amount of electric charge of the ions of one polarity that are formed in air by ionising radiation and the mass of the air.
  Unit : C. kg^{-1} (see also Roentgen)

- **Gamma radiation:** Photon radiation emitted by an excited atomic nucleus decaying to a lower energy state. Gamma radiation has a line spectrum with photon energies which are specific to the nuclide concerned. Gamma and X-rays are both electromagnetic radiation and they are distinguished only by their mode of generation.

- **Gray:** The SI unit of absorbed radiation dose. 1 Gray of absorbed dose corresponds to 1 joule of energy per kilogram of mass.
  1 Gray = 100 rad

- **Half-thickness:** The thickness of material layer that reduces the intensity of initial radiation by a factor of two.

- **Ionising radiation:** Radiation that consists of particles capable of ionising a gas.

- **Isotopes:** Nuclides with the same atomic number but different atomic weights. (Mass numbers)

- **Mass per unit area:** Product of the density of a material and its thickness.

- **Nuclide :** Generic term for neutral atoms that are characterized by a specific number of neutrons N and protons Z in the nucleus.

- **Quality factor :** A factor which in radiation protection allows for the effects of different types of radiations and energies on people.

- **Rad (Radiation Absorbed Dose):** An old unit used to measure absorbed radiation dose. 1 Rad of absorbed dose corresponds to 0.01 joule of energy per kilogram of mass (=100 ergs of energy per gram of mass).
  All measurements of absorbed dose depend on the absorbing medium as well as the level of radiation. 1R is equivalent to 0.871 rad in air.

- **RBE (Relative Biological Effectiveness)**
  The biological effect of radiation depends, not only on the energy absorbed, but also on the radiation concerned. To illustrate, the effect of 1 Gray of X-ray will be quite different from the effect of 1 Gray of neutrons. The RBE is an attempt to compensate for this variation and may be considered as a weighting factor for different type of radiation.
  RBE (for radiation of Energy E) is defined as the ratio; (Dose of 200 keV gamma rays producing a given biological effect) divided by (dose of radiation of energy E producing the same effect).

- **Radioactivity :** The property which certain nuclides have of emitting radiation as a result of spontaneous transitions in their nuclei.

- **rem (Roentgen Equivalent Man) :** The rem is an early unit used to measure the effect of a given type of radiation on living tissue, including compensation for the type of radiation involved.
  rem dose = rad dose x RBE

- **Roentgen-R :** An old unit used to measure radiation by it's ability to ionise air. 1 Roentgen is that amount of radiation which releases a charge of 258 microcoulomb per kilogram of air. This measure is a specific quantity of radition, but does not relate to the absorption by materials.

- **Sievert (Sv) :** This is the SI unit used to measure the effect of a given type of radiation on living tissue, including compensation for the type of radiation involved.
  1 Sievert = 100 rem

- **H* (10) :**
  (Normally pronounced "H-Star-Ten")
  This is the Ambient Dose Equivalent and is applicable to strongly penetrating radiation in environmental and area monitoring. The exact definition is complex (defined in ICRU Report 39), but relates generally to the effect of the radiation at a depth of 10 min. in human tissue.

ACITIVITY & DOSERATE CALCULATION PROCEDURE

ACTIVITY & DOSERATE CALCULATION PROCEDURE

a. Activity calculation (as on date)

It is known that, given the activity at any previous date and by knowing its half-life we can calculate the present activity by using the following equation.

$$A = A_0 e^{-\lambda t}$$
$$= A_0 e^{-(0.693/T1/2)\,t}$$

Where,

A	=	Present activity
A_0	=	Activity as on previous date
$T_{1/2}$	=	Half life of source
t	=	Elapsed time
λ	=	Decay constant

TYPICAL CALCULATION OF ACTIVITY FOR TWO BETA AND TWO GAMMA SOURCES:

BETA SOURCES:

Sr-90: (3.7 KBq, Oct 2006); Half life for Sr-90 is $T_{1/2}$ = 28.5Yrs

Activity (A_0) = 3.7 KBq, as on Oct'06.
= 3700 Bq
(Elapsed time till Sept'07= 11months)

Present activity (A) = $A_0 e^{-(0.693/T1/2)\,t}$; as on Sept'07
$T_{1/2}$ = 28.5yr
t = 11/12=0.9166yr
= $3700\, e^{-(0.693/28.5)\,0.9166}$
= 3618.6 Bq

TI-204: (11.1 KBq, Oct 2006); Half life for Tl-204 is $T_{1/2}$ = 4Yrs

Activity (A_0) = 11.1 KBq, as on Oct'06.
= 11100 Bq
(Elapsed time till Sept'07= 11months)

Present activity (A) = $A_0 e^{-(0.693/T1/2)\,t}$; as on Sept'07
$T_{1/2}$ = 4yr
t = 11/12=0.9166yr
= $11100\, e^{-(0.693/4)\,0.9166}$
= 9469.41 Bq

GAMMA SOURCES:

Cs-137: (3.1μCi, July'07) ; Half life for Cs-137 is $T_{1/2}$ = 30Yrs

Activity (A_0) = 3.1μCi, as on Oct'06.
= $3.1X3.7X10^{10}X10^{-6}$
= 114700 Bq
(Elapsed time till Sept'07= 2months)

Present activity (A) = $A_0\, e^{-(0.693/T_{1/2})\, t}$; as on Sept'07
$T_{1/2}$ = 30yr
t = 2/12=0.1666yr
= $114700\, e^{-(0.693/30)\, 0.1666}$
= 114264.14 Bq

Co-60: (3.7μCi, July'07) ; Half life for Co-60 is $T_{1/2}$ = 5.3Yrs

Activity (A_0) = 3.7μCi, as on Oct'06.
= $3.7X3.7X10^{10}X10^{-6}$
= 136900 Bq
(Elapsed time till Sept'07= 2months)

Present activity (A) = $A_0\, e^{-(0.693/T_{1/2})\, t}$; as on Sept'07
$T_{1/2}$ = 5.3yr
t = 2/12=0.1666yr
= $136900\, e^{-(0.693/5.3)\, 0.1666}$
= 133961.2 Bq

b. DOSE RATE CALCULATION

Doserate can be calculated by using the following formula

$$\text{Doserate} = \frac{\text{Source Activity x gamma constant}}{(\text{Distance})^2}$$

where
Doserate is in mR (milli Roentgen)
Source Activity is in mCi (milli Curies)
Distance is in cm (Centimeters)
Gamma constant for Cs-137 is 3300
and gamma constant for Co-60 is 13200

Examples :

1. Calculate the doserate at a distance of 20 cm from a Cs-137 source of activity 10 mCi

$$\text{Doserate} = \frac{10 \times 3300}{(20)^2} = \frac{33000}{400} = 82.5\text{mR}$$

2. Calculate the distance from a Co-60 source of activity 20 mCi to obtain a doserate of 50mR

$$50\text{mR} = \frac{20 \times 13200}{(\text{Distance})^2}$$

$$\text{i.e. } (\text{Distance})^2 = \frac{20 \times 13200}{50} = 5280\ \text{cm}^2$$

$$\therefore \text{Distance} = \sqrt{5280} = 72.66\ \text{cm}$$

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